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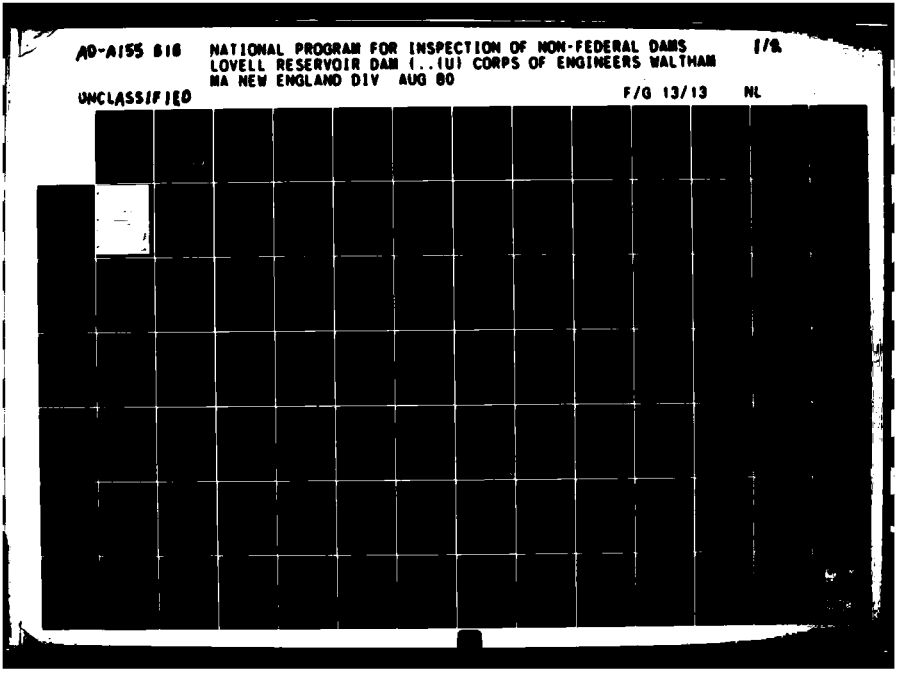

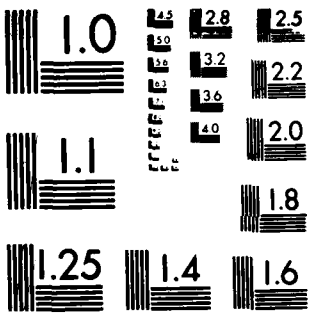

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MERRIMACK RIVER BASIN

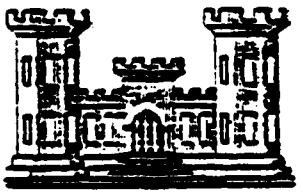
FITCHBURG, MASSACHUSETTS

LOVELL RESERVOIR DAM AND DIKE

DAM ——— MA 00872

DIKE ——— MA 01334

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASS. 02154

AUGUST 1980

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

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Merrimack River Basin
Fitchburg, Massachusetts
Falulah Brook

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The project is comprised of an 800 ft. long 80 ft. high earthfill main dam and an 18 ft. high, 1600 ft. long earthfill dike. The project has a size of intermediate and a hazard potential of high. Both are generally in fair condition.

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Honorable Edward J. King
Governor of the Commonwealth of Massachusetts
State House
Boston, Massachusetts 02133

Dear Governor King:

Inclosed is a copy of the Lovell Reservoir Dam and Dike Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. In addition, a copy of the report has also been furnished the owner, City of Fitchburg Water Department, Fitchburg, Mass.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for your cooperation in carrying out this program.

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

NATIONAL DAM INSPECTION PROGRAM

PHASE I INVESTIGATION REPORT

BRIEF ASSESSMENT

Identification No.: MA 00872 (Dam), MA 01334, (Dike)

Name of Dam: Lovell Reservoir Dam and Dike

City: Fitchburg

County and State: Worcester County, Massachusetts

Stream: Falulah Brook

Date of Inspection: April 11, 1979 (Dam), June 17, 1980, (Dike)

The project is comprised of an 800 foot long, 80 foot hydraulic height, earthfill main dam, and a 18 foot hydraulic height, 1,600 foot long earthfill dike. The main dam has a 78.5 foot long concrete spillway with a 450 foot long concrete and stone outlet channel. Completed in 1929, the project has always been owned and operated by the City of Fitchburg as a part of their water supply system.

Lovell Reservoir receives inflow from Falulah Brook, with a contributing drainage area of 2,070 acres (3.24 s.m.).

The project has a size classification of intermediate and a hazard classification of high. Based on Corps guidelines the test flood would be the full probable maximum flood (PMF). This assumed test flood will produce a calculated inflow of 6,480 cfs with a resulting outflow of 5,920 cfs, which would overtop the dam and dike by about 0.3 feet to elevation 770.8. The spillway has a capacity of 4,320 cfs (to top

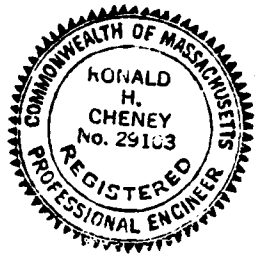
of dam elevation 770.5) which is approximately 73 percent of the test flood outflow. There is no record of the dam or dike being overtopped by storm water runoff in the past.

There was no indepth engineering data available, and therefore, the condition of the project was primarily evaluated by visual inspection, past performance history, and sound engineering judgement.

The dam and dike are generally in fair condition. It is recommended that the owner engage a qualified registered professional engineer to implement the following: 1) investigate seepage at the abutment and embankment of the dam and design remedial measures if needed, 2) evaluate the effect of earthquake shaking on the integrity of the concrete core wall of the dam, 3) specify procedures for removal of trees and their root systems from the downstream slope of the dike, 4) design remedial measures for riprap slope protection of the upstream slope of the dike, 5) perform an indepth hydraulic/hydrologic study to determine the adequacy of the spillway and outlet channel and design required modifications.

Furthermore, the owner should implement the following remedial measures: 1) maintain all slopes free of trees and brush, 2) maintain a proper height of grass cover on the slopes, 3) remove trees and brush from the spillway outlet channel bottom and slopes above the outlet channel walls, 4) test all valves on pipes to insure they are functioning and repair those which need maintenance, 5) backfill all animal burrows with properly compacted fill, 6) repair erosion gullies at the dam left and right abutment areas and adjacent to the spillway training wall with compacted gravel, 7) repair the spillway channel upstream of the masonry falls, 8) establish a formal warning and monitoring system to notify downstream areas in the event of an emergency

and 9) institute a program of annual technical inspection. These recommendations and remedial measures should be implemented by the owner within one year after receipt of this Phase I Investigation Report.



Ronald H. Cheney, P.E.
Vice President

Hayden, Harding & Buchanan, Inc.
Boston, Massachusetts

This Phase I Inspection Report on Lovell Reservoir Dam and Dike has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Richard J. DiBuono

RICHARD DIBUONO, MEMBER
Water Control Branch
Engineering Division

ARAMAST MAHTESIAN, CHAIRMAN
Geotechnical Engineering Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation: however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to

assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

CONTENTS

Section	Page
Letter of Transmittal	
Brief Assessment	
Review Board Page	
Preface	i
Table of Contents	iii-v
Overview Photo	vi
Location Map	vii

REPORT

1. PROJECT INFORMATION	
1.1 General	1
a. Authority	1
b. Purpose of Inspection	2
1.2 Description of Project	
a. Location	2
b. Description of Dam and Appurtenances	2
c. Size Classification	3
d. Hazard Classification	4
e. Ownership	4
f. Operator	4
g. Purpose of Dam	4
h. Design and Construction History	5
i. Normal Operating Procedures	5
1.3 Pertinent Data	5
2. ENGINEERING DATA	
2.1 Design Data	10
2.2 Construction Data	10
2.3 Operation Data	10
2.4 Evaluation of Data	10

Section

3. VISUAL INSPECTION

3.1 Findings 12

a. General 12
b. Dam and Dike 12
c. Appurtenant Structures 16
d. Reservoir Area 18
e. Downstream Channel 18

3.2 Evaluation 18

4. OPERATIONAL PROCEDURES

4.1 Procedures 20

4.2 Maintenance of Dam 20

4.3 Maintenance of Operating Facilities 20

4.4 Description of any Warning System in Effect 20

4.5 Evaluation 20

5. HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features 22

a. General 22
b. Design Data 22
c. Experience Data 22
d. Visual Observation 23
e. Test Flood Analysis 23
f. Failure Analysis 24

6. STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability 26

a. Visual Observation 26
b. Design and Construction Data 26
c. Operating Records 27
d. Post-Construction Changes 28
e. Seismic Stability 28

Section

7. ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam and Dike Assessment 29

a. Condition 29
b. Adequacy of Information 29
c. Urgency 29
d. Need for Additional Investigation 30

7.2 Recommendations 30

7.3 Remedial Measures 30

a. Operation and Maintenance Procedures 30

7.4 Alternatives 31

APPENDIXES

APPENDIX A - INSPECTION CHECKLIST A-1

APPENDIX B - ENGINEERING DATA B-1

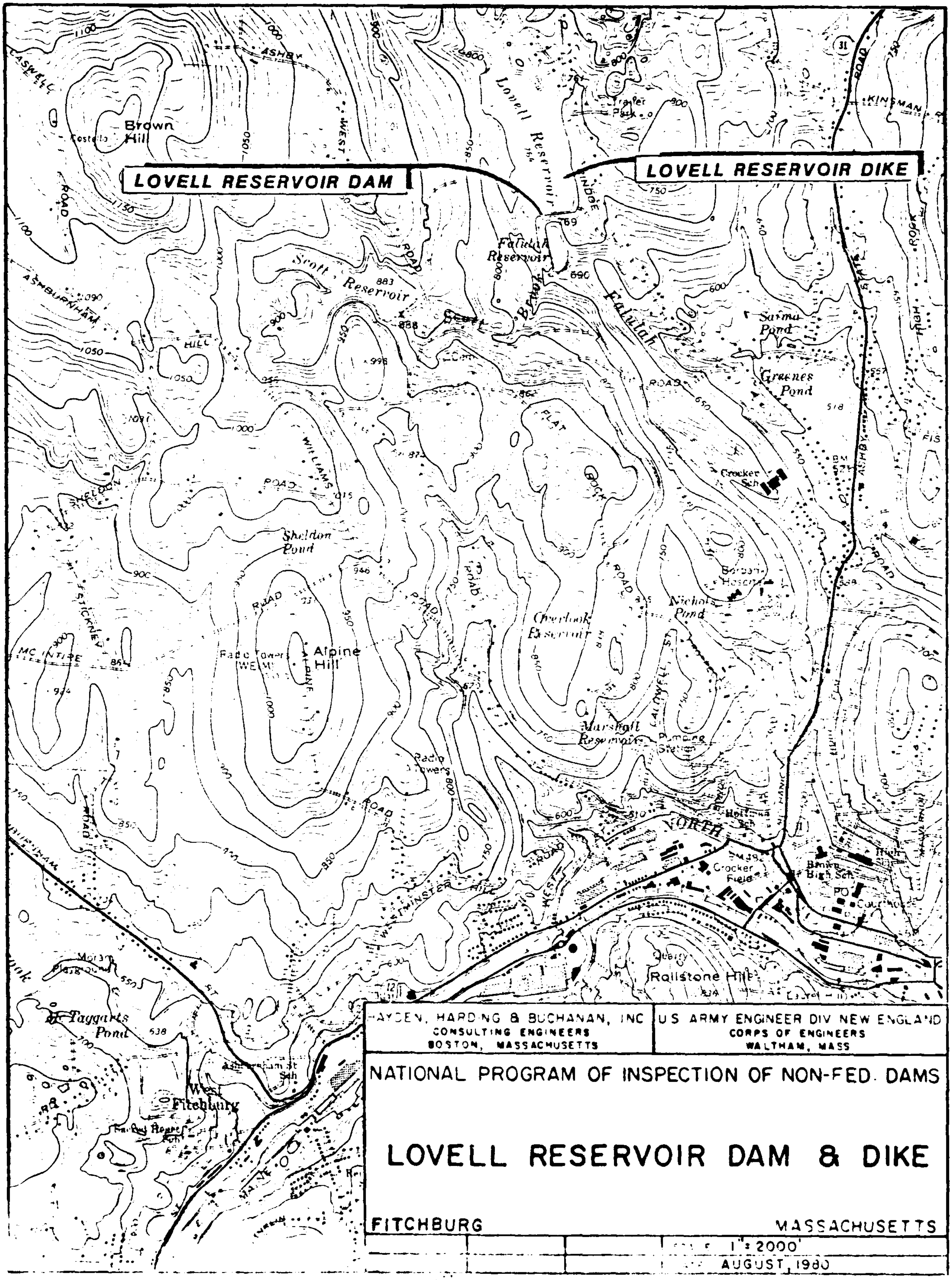
APPENDIX C --PHOTOGRAPHS C-1

APPENDIX D - HYDROLOGIC AND HYDRAULIC COMPUTATIONS D-1

APPENDIX E - INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS E-1

LOVELL RESERVOIR DIKE

LOVELL RESERVOIR DAM



HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON, MASSACHUSETTS

U.S. ARMY ENGINEER DIV NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOVELL RESERVOIR DAM & DIKE

FITCHBURG MASSACHUSETTS

SCALE 1"=2000'

DATE AUGUST, 1980

PHASE I
NATIONAL DAM INSPECTION PROGRAM

NAME OF DAM: LOVELL RESERVOIR DAM AND DIKE

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Hayden, Harding & Buchanan, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed was issued Hayden, Harding & Buchanan, Inc. under a letter of 28 November 1978 from Max B. Scheider, Colonel, Corps of Engineers. Contract No. DACW 33-79-C-0012 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location

Lovell Reservoir is located in the City of Fitchburg in Worcester County, Massachusetts. Lovell Reservoir is formed by Falulah Brook and is located approximately 400 feet upstream of Falulah Reservoir. The dam is shown on the Fitchburg, Massachusetts Quadangle with the approximate coordinates of 42° 37' 00" North by 71° 49" 12' West. The attached dike is north of the left dam abutment.

b. Description of Dam and Appurtenances

Dam

The project is comprised of a 80± foot high (hydraulic height), 800± foot long earth embankment dam containing a concrete core wall, an earthfill dike and an emergency spillway. The downstream dam embankment slopes are inclined at 2H:1V and are turf covered. The upper 25± feet of the upstream slope is inclined at 2H:1V and has a riprap layer up to the high water level. Below the upper 25± feet, there is no riprap protection and the side slopes are inclined at 2.5H:IV (see plans appendix B). The upper portion above the riprap is turf covered as shown by Photo 4. The crest has a width of about twelve feet. The core wall has a height of approximately 91 feet, with a top elevation of 766.5±, 4 feet below the crest of dam.

The emergency spillway, located at the right side of the dam, traverses around Falulah Reservoir and converges with Scott Brook about 1,400 feet downstream. Located at about the midpoint of the dam embankment are the intake well and controls. See photographs 1,2,8,11 and plans within Appendix B.

The dike is a 18 foot high (hydraulic height) earth embankment extending about 1,600 feet north from the main dam at the left side. The dike contains a concrete core wall throughout its length. The upstream and downstream sides are inclined at about 2H:1V and the crest has a width of 12 feet. The upstream side slope is riprapped to the high water level.

There are 3 intake pipes leading to the intake well. There is an upper 16 inch inlet at invert elevation 739, a 16 inch intermediate invert at elevation 714 and a lower 30 inch inlet at invert elevation 688. The intake structures for these lines are located 65, 130 and 200 feet upstream of the crest respectively. The intake structure contains manually operated sluice gates which control the intake lines as shown by photo 11. The outflow from the well exits through a 30 inch C.I. pipe at invert elevation 687.5. The 30 inch line eventually reduces to a 12 inch bubbler which outlets into Falulah Reservoir and a 12 inch main line which feeds to a downstream chlorination building and into the City water system. These two lines are controlled by downstream gate valves located at the toe area of the embankment.

c. Size Classification

The size of the project (dam and dike) is classified as intermediate based on its storage capacity of 1,173 acre-feet and hydraulic heights of 80 feet and 18 feet, respectively.

d. Hazard Classification

The project has a high hazard potential classification. An assumed failure of the dam or dike will cause a discharge of 216,530 cfs and 15,400 cfs, respectively. The dam and dike have separate failure impact areas which converge approximately 5000 feet downstream of the dam at Greenes Pond.

Assuming the dam fails, flood stage within the first impact area will reach depths of six to 24 feet, including initial spillway discharge prior to dam failure. At least 30 houses and several roads will be flooded. The potential for loss of a significant number of lives is high. Beyond the first impact area additional damage and loss of lives will occur.

Assuming the dike fails, flood stage within the impact area will be four to twelve feet deep. At least seven houses and several roads will be damaged. The potential for loss of many lives is high. Beyond the first impact area additional damage and loss of lives will occur.

e. Ownership

The project has been owned by the City of Fitchburg Water Department since it was constructed in 1929.

f. Operator

The operator of the project is Mr. J. Andre Provincial, the City of Fitchburg Water Department superintendent. The address of the Water Department is 718 Main Street, City Hall, Fitchburg, Massachusetts 01420. Telephone (617) 342-5722.

g. Purpose of Dam

The purpose of the project is water supply for the City of Fitchburg.

h. Design and Construction History

The project was designed in 1927 by the City of Fitchburg Water Department. Construction began in 1927 and was completed in 1929. In 1968, minor concrete repairs were made to the spillway.

i. Normal Operational Procedure

According to Water Department personnel, depending on the water level in Lovell Reservoir, the two upper inlet sluice gates (see photograph 11), are usually kept open. Water flows into the intake well and exists through a 30 inch pipe. At the downstream toe of dam, the water flows into two twelve inch lines. Here, water flows into Falulah Reservoir, photograph 2, from one twelve inch line or continues directly downstream in the other twelve inch line to a chlorination building. Both 12 inch lines have manually operated valves located at the toe area of the dam. The line discharging into Falulah Reservoir is normally kept partially opened. The other 12 inch line is normally kept open. Outflow to the chlorination building is controlled by a downstream regulating station as water demand within the City supply system varies.

Small trees and brush growth sited in previous state inspection reports have been cleared between 1977 and 1978.

1.3 Pertinent Data

a. Drainage Area

The drainage area of 2,070 acres (3.24 s.m.) is comprised of moderately sloped, wooded, undeveloped land. Several improved roads pass through the drainage area. They are Rindge Road, Ashby West Road, and Jewell Hill Road. There are also several unpaved roads. About forty homes are scattered throughout the drainage area, along the improved roads. There are also several Water Department buildings at various locations.

There are several brooks and swamps within the drainage area. Falulah Brook connects Lovell Reservoir to Fitchburg Reservoir, about 10,000 feet upstream. The brook has a change in elevation of about 216 feet over this distance. Another brook (unnamed) flows into Falulah Brook approximately one mile upstream of Lovell Reservoir. This brook is about 8,000 feet long and begins near Jewell Hill. It has a change in elevation of about 300 feet. Immediately below the dam is the Falulah Reservoir (see photograph 2) and the intake building for the water supply system.

b. Discharge at Damsite

The dam has 3 intake pipes and one outlet pipe. Sixteen inch intake pipes are located at elevations 739 and 714. A 30 inch intake pipe is at elevation 688.0 and has a screened inlet at elevation 693±. (See plan in Appendix B).

The 30 inch outlet pipe is at elevation 687.5. Near the downstream toe of the dam, it reduces to a 24 inch pipe which then splits into two 12 inch lines. One 12 inch line connects to the water distribution system. The other 12 inch line connects to an aerator in Falulah Reservoir (photograph 2), which outlets at elevation 689±.

The project was completed in 1929. It has been subjected to various storms but no record of maximum flood outflows are available.

The spillway (see photograph 8) has no provisions for flashboards, stop logs or gates. It has a capacity of 4,320 cfs at elevation 770.5, top of dam.

The PMF test flood will overtop the dam by about 0.3 foot to elevation 770.8. The spillway outflow would be 4,750± cfs. The total project discharge will be 5,920 cfs, which includes overtopping outflow.

c. Elevation (ft. above NGVD)

(1) Streambed at centerline of dam ---------- 690±

(2) Maximum tailwater ---------- N/A

(3) Upstream portal diversion tunnel ---------- none

(4) Normal pool ---------- 764.0

(5) Full flood control pool ---------- N/A

(6) Spillway crest ---------- 764.0

(7) Design surcharge (Original Design) ---------- unknown

(8) Top of Dam and Dike ---------- 770.5

(9) Test flood design surcharge ---------- 770.8

d. Reservoir

(1) Length of maximum pool ---------- 3200'

(2) Length of water supply pool ---------- 3200'

(3) Length of normal pool ---------- 3200'

(4) Length of flood control pool ---------- N/A

e. Storage (acre-feet)

(1) Test flood pool ---------- 1185

(2) Top of dam ---------- 1173

(3) Spillway crest pool ---------- 914

(4) Water supply pool ---------- 914

(5) Normal pool ---------- 914

(6) Flood-control pool ---------- N/A

f. Reservoir Surface (acres)

(1) Top of dam ---------- 56

(2) Test flood pool ---------- 56

(3) Spillway crest ---------- 33

(4) Water supply pool ---------- 33

(5) Normal pool ---------- 33

(6) Flood-control pool ---------- N/A

g. Dam and Dike

(1) Type ----------gravity, earth fill

(2) Length ---------- 800' dam; 1600' dike

(3) Height (maximum structural) --------- 95' dam; 27' dike

(4) Top width ---------- 12'

(5) Side Slopes ---------- D.S. grassed 2H:1V
U.S. (upper 25') riprap 2H:1V, (below upper 25'±) 2.5:1V

(6) Zoning ---------- indicated on plan

(7) Impervious Core ----------concrete core wall

(8) Cutoff ---------- concrete core wall

(9) Grout curtain ---------- not included on plans

(10) Other ----------along toe of dam, several 6" collector pipes draining into Falulah Reservoir

h. Diversion and Regulating Tunnel ---------- none

i. Spillway

(1) Type ---------- concrete, broad crested

(2) Length of weir ----------78.5' effective length

(3) Crest elevation ---------- 764.0

(4) Gates ---------- none

(5) U/S Channel ---------- riprap 5H:1V slope with concrete training walls

(6) D/S Channel ---------- 450' long, masonry/concrete wall stone bottom channel, width varies 70' to 40'

j. Regulating Outlets

The regulating outlets is the 30 inch outlet pipe described in section 1.3b. This 30 inch pipe, invert elevation 687.5, is controlled by a manually operated sluice gate at the intake structure, which is normally left in the open position. Near the downstream toe of the dam, the 30 inch pipe is reduced to a 24 inch line and then into two 12 inch branch lines. Both of the 12 inch lines are gated. One 12 inch gate is kept open. The second gate is usually partially open, to feed water into Falulah Reservoir. Flow through the fully open 12 inch line is controlled downstream by valves at a regulating station.

SECTION 2

ENGINEERING DATA

2.1 Design

The project was designed in 1927. Construction drawings are signed by the City of Fitchburg Commissioner of Public Works. Design plans were located at the Worcester County Court House, Engineering Department and the Engineering Office at Fitchburg City Hall. No design calculations were located.

2.2 Construction

Design plans dated 1927 through 1929 and a plan showing spillway repairs in 1968, were located at the Fitchburg Engineering Office. The former indicate changes which occurred during construction. Inspection reports prepared during construction were available at the Worcester County Court House, Engineering Office.

2.3 Operation

No operational manual exists for this dam.

2.4 Evaluation

a. Availability

Design plans and inspection reports prior to 1969 were made available at the Worcester County Court House Engineering Department, Worcester, Massachusetts. Revised design plans dated 1927 to 1929 and spillway repairs made in 1968, were made available at the Fitchburg City Hall Engineering Office. State Inspection Reports for the years 1975 and 1976 were made available at the Massachusetts Department of Environmental Quality Engineering, Division of Waterways Office at Boston.

b. Adequacy

The lack of indepth engineering data does not allow for a definitive review. The adequacy of the data does not permit a structural and hydraulic review of the dam from the standpoint of design calculations, but must be based primarily on the visual inspection, past performance history and sound engineering judgement.

c. Validity

The field investigation indicates that the external features substantially agree with those shown on the plans dated 1927 to 1929. Plans were obtained which show a proposed design and as-built features. Piping and gate valve arrangements are not accurately shown on these plans as changes have been made periodically, and records were not updated.

SECTION 3

VISUAL INSPECTION

3.1 Findings

a. General

Lovell Reservoir Dam was inspected on April 11, 1979. The dike was inspected on June 17, 1980. During the April 1979 inspection, water was flowing from the spillway. The depth of water was about 1 inch. Several areas where seepage was significant were noted and recorded. Evidence of tree and brush growth on the embankment, which were recently removed, could be seen. During the June 1980 inspection, the water level of the reservoir was 2 feet below the spillway crest. There was considerably more brush growth evident during the later inspection.

b. Dam and Dike

The main dam consists of an embankment section about 800 feet long with a structural height of 94 feet. A chuted spillway structure approximately 78.5 feet long passes around the dam on the right abutment. An embankment dike approximately 1,600 feet long with a maximum structural height of 27 feet continues from the left abutment of the dam along the eastern edge of the reservoir. Photograph 6 shows the crest and upstream slope of the main dam in the foreground and the dike in the background as viewed from the spillway crest. The dike and dam contact can be seen in the background of the photo.

1. Dam

Upstream Slope

The upstream face of the dam is on a slope of 2H:1V. Riprap slope protection extends to within 13 linear feet of the dam crest, and the water level at the time of inspection was only 1 foot below the top of the riprap. There is some evidence of wave erosion near the right abutment. The visible riprap is in good condition, and the grass-covered upstream face above the riprap shows no evidence of sliding or slumping.

Crest

The crest of the dam is approximately 12 feet wide. As shown in Photograph 3, there is a sand and gravel roadway on the crest. No cracking or misalignment of the embankment is evident.

Downstream Slope

The downstream face, shown in Photographs 1 and 7 is on a slope of 2H:1V. A stone-paved drainage bench approximately 5 feet wide is located near the mid-height of the face to intercept and route surface runoff to a drainage ditch on the left abutment. Small erosion gullies were observed downslope from the bench near its contact with the left abutment, indicating occasional overflow around the ditch. Erosion gullies were also observed at the right abutment contact near the spillway.

Wet areas and standing water up to 3 inches deep were observed at the toe of the slope near the right and left abutments. These areas are fed by seepage observed at the contacts of the dam with abutments. Photographs 12 and 13 show seepage at the right abutment contact. Photograph 14 shows a large wet area

on the left abutment about 65 feet downstream from the toe. Much of the water in this area is drained through a pipe, shown in Photograph 16, beneath a gravel roadway into Falulah Reservoir, about 150 feet downstream from the dam.

The central one third of the toe area has been filled with sand and gravel to improve access to the valves located at this area. The condition of the filled area during the April 1979 inspection was dry, however, records of past inspections indicate that this area was wet before it was filled with sand and gravel. See photograph 14.

All water exiting at the right and left abutments appears to be clear.

Approximately 15 feet above the toe elevation, water exits through the downstream face of the main embankment in a series of small seeps extending at least 60 feet across the face, Photograph 17. The water from these seeps appeared silty, as shown in Photograph 18. The silt that was observed may have been due to local disturbance caused by uncovering the seeps. However, the area around the seep was silty and this is a significant observation which requires further immediate study.

Seepage through the downstream face and the abutment contacts was noted in dam inspections between 1931 and 1935, but at that time, the seepage was judged not to be serious. Slumping of the downstream slope near the toe was also reported. A recent inspection (1975) by the Massachusetts Department of Environmental Quality Engineering (DEQE) also identified seepage at the downstream toe and wet areas near the abutment contacts, and consequently, DEQE classified the dam as unsafe.

At the time of the April 1979 inspection, the downstream face of the main embankment had been cleared of small trees and brush growth which had been reported in the Commonwealth of Massachusetts inspection reports in 1975 and 1976. According to a representative of the Fitchburg Water Department, the brush had been cleared between 1977 and 1978. A few small animal burrows were observed on the downstream face of the main embankment.

2. Dike

The dike is an earth embankment which abuts the left end of the main dam in a continuous manner. The dike has a maximum hydraulic height of about 18 feet and continues along the eastern edge of the reservoir in a sinuous manner for a distance of about 1600 feet.

Upstream Slope

The upstream slope is inclined at 2H:1V. The slope is protected by riprap to an elevation 3 feet below the crest. Over the large majority of the slope, the riprap is in good condition. A typical portion of the upstream slope is shown in Photo 23. There are two areas where the riprap is in poor condition. At a location of about 920 feet right of the left abutment, there has been a slump failure of the riprap. This slump area is shown in Photo 26. The slump is about 25 feet long and extends below the waterline. The riprap in the slump area is of smaller size than was generally used on the slope. A second area of small sized riprap is shown in Photo 27. The riprap in this area has also slumped slightly and as shown in the photo is becoming overgrown with vegetation.

The area of the slope above the riprap is covered with dense vegetation as shown in Photo 23. Most of the vegetation is second growth maple trees. Trees had been cut but stumps were not removed and there is a significant regrowth as can be seen in Photo 25.

Crest

The crest of the dike is about 12 feet wide and is unpaved. Vehicles may drive along the entire crest gaining access from the right abutment area. Vehicular traffic has caused minor erosion of the crest surface as shown in Photo 24. No misalignment or unusual settlement of the crest was observed.

Downstream Slope

The downstream slope is inclined at 2H:1V. The slope is covered with dense vegetation including many trees of varying sizes. This overgrown condition may be seen in Photos 28 and 29. Many of the trees are dead or dying. The vegetation is so dense that an adequate inspection of the slope could not be made.

A rockfill was observed at the toe of the downstream slope in several areas along the toe. It appears that the rockfill is continuous along the downstream toe.

No seepage or wet areas were observed but due to dense vegetation, an adequate examination for these features could not be made.

c. Appurtenant Structures

The approach channel to the concrete spillway was submerged and could not be inspected during the April 1979 inspection. The overall condition of the spillway is generally

good. The discharge channel floor is paved with rock and appears to be in fair condition. Brush growing in the discharge channel is shown in Photograph 9. The main embankment adjacent to the left training wall of the spillway on the upstream face contains some minor erosion gullies.

The dam has a 78.5 foot wide by 6.5 foot high concrete spillway crest. The approach channel is paved with stone masonry which is sloped upward toward the spillway crest. The concrete sidewalls are curved. The upstream channel width varies from 100 feet to 78.5 feet. The outlet channel varies from 78.5 to 40 feet wide.

The outlet channel is 450± feet long. It has a stone masonry bottom and concrete walls. The spillway crest drops about 4 feet at the outlet channel. The channel has many small, 1 to 2 inch trees growing in the stone masonry bottom. At the end of the concrete portion of the channel, there is a stone masonry waterfall about 8 to 10 feet high, as shown by photograph 10. The state inspection report of 1975 refers to a collapse in the channel floor upstream of the waterfall and a hole in the toe of the east downstream side wall with water outflow. Due to spillway discharge at time of April 1979 inspection, these features could not be verified. However, during the June 1980 inspection, there was no discharge into the spillway and these features could be observed. Photographs 21 and 22 show the extent of the erosion of the channel floor. Although these conditions are quite distant from the dam and do not affect dam safety, they should be repaired. The overall condition of the vertical section of the waterfall is generally good.

The channel below the waterfall, photograph 20, is excavated through natural ground in a narrow valley. Some areas have stone masonry sidewalls. There are trees and boulders within the channel. The channel joins Scott Brook near Falulah Reservoir.

The intake structure, photograph 11, is located near the center of the main dam. The proposed building to house the intake gate valve controls was apparently never constructed. The 30 inch intake valve is reported inoperable and open. Two 16" intake valves are reported to be operable. Aside from the inoperable gate valve, the surficial exterior features appeared to be in generally good condition.

The toe of dam area was observed to be different from the design plans. The outlet pipes are buried and the area was recently regraded. Several six inch diameter drains are evident entering into Falulah Reservoir, see photographs 17 and 19.

d. Reservoir Area

The area around the reservoir is undeveloped. A detailed description of the drainage area is given in Section 1.3.b of this report.

e. Downstream Channel

Water is channeled through a 30 inch outlet pipe into two 12 inch pipes. One pipe leads into the Falulah Reservoir, which is about 150 feet downstream from the Lovell Reservoir dam embankment, and the other feeds into the City water system.

3.2 Evaluation

Visual examination indicates that the dam is in fair condition with respect to the geotechnical aspects. Seepage was

observed through the downstream embankment face, the embankment-abutment contacts, and the downstream on the left abutment. This seepage, if not adequately controlled, could lead to failure of the dam.

Visual examination indicates that the dike is in fair condition with respect to geotechnical aspects. Dense vegetation on the downstream slope did not allow an adequate examination of this slope and the downstream toe.

The presence of root systems of large trees, many dead or dying on the downstream slope of the dike could create shortened seepage paths which could lead to internal erosion of the dike.

The poor riprap protection at two locations on the upstream slope could lead to erosion failures during periods of intense wave action.

The 30 inch intake valve is reported to be inoperable. The spillway outlet channel floor and slopes contain trees and brush.

Extensive erosion of the outlet channel floor, just upstream of the masonry falls, was observed during the June 1980 inspection.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedure

The purpose of the project is for water supply. The intake gates are normally left open and water in the intake well flows to a downstream chlorination building and eventually into the City system. Water from the intake well also flows into the downstream Falulah Low Pressure Distributing Reservoir. Downstream gate valves control both outflow lines and a downstream regulating station controls the combined outflow from Falulah and Lovell Reservoirs prior to entering the City distibution system.

4.2 Maintenance of Dam

The City of Fitchburg is responsible for maintenance of the dam and dike. The most recent maintenance occurred in 1977 when vegation on the downstream embankment face of the dam was removed and gravel was placed over the wet central toe area for ground stabilization.

4.3 Maintenance of Operating Facilities

There is no formal operational maintenance program. The most recent maintenance occurred in 1977, when the downstream gate valves were replaced.

4.4 Description of Warning System

There are no warning systems at this facility.

4.5 Evaluation

There is no formal operational procedure for this project. The project is an integral part of the City water supply and therefore deficiencies in operational facilities would be readily detected in normal operations. Seepage through the dam embankment was observed

and no apparent measures have been instituted to monitor or retard this flow except for the gravel fill placed at the downstream toe area. The owner should institute a program of annual technical inspection for the dam and dike.

SECTION 5

HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. General

The project was designed and is used for water supply. The main dam has a hydraulic height of 80 feet and is about 800 feet long. An earth dike extends from the main dam along the east side of the reservoir for about 1600± feet. The maximum hydraulic height of the dike is approximately 18 feet. The useable storage capacity is 914 acre feet. Photographs 1,3,6 and 8 show views of the main dam and dike. See Appendices B, C & D.

b. Design Data

The project was completed in 1929. Design calculations were not located. Drawings showing proposed work were found. The project was designed and has always been used for water supply.

c. Experience Data

Overtopping of the dam or the dike has never been reported. Spillway discharge measurements have not been taken. During the August 17 to 20, 1955 flood period, about 4 inches of rainfall occurred in the Fitchburg area. Gage station 1-0945 is maintained by th U.S.G.S. on the North Nashua River near Leominster. It recorded a maximum discharge of 16,300 cfs (152.34 cfs/s.m.) for a 107 s.m. drainage area on March 18, 1936. A state report dated August 17, 1936, indicated a "washout of lower part of waste way apron", but there were no other records of any problems, or when they actually occurred.

The level of the reservoir varies. However, discharge through the spillway normally occurs each year. At times, the reservoir water level has been 20 feet or more below the spillway crest. Based upon observed growths of small trees within the outlet channel, spillway outflow is probably not significant, see photograph 9.

d. Visual Observations

The dam and dike show no indications of having been overtopped. During the April 1979 inspection, water was discharging from the spillway at the rate of approximately 7 cfs. During the June 1980 inspection, the water level of the reservoir was approximately 2 feet below the spillway crest. Small trees of 1 and 2 inch diameter, were growing in the stone masonry outlet channel floor. Observations of the drainage area and general vicinity show them to be generally as indicated on the U.S.G.S. map and as described in Section 1.3 of this report.

e. Test Flood Analysis

Based on Corp Guidelines and the project's intermediate size and high hazard potential classifications, the test flood used was the PMF. The PMF inflow is 6480 cfs for the 2070 acre (rolling hills) drainage area. With the initial water level assumed at the spillway elevation of 764, the test flood would surcharge the reservoir to elevation 770.8, 0.3 feet above the top of the dam.

The spillway is capable of passing an outflow of 4,320 cfs. The remaining outflow, 1600 cfs, would overtop the main dam and dike. The 450 foot long spillway outlet channel can just carry the entire 4,320 cfs outflow within its defined sidewalls and banks. The brook channel beyond can not carry this outflow. Water would flow above the top of the channel into the adjacent woods. See photographs 3,9, 10 and 20.

f. Failure Analysis - Dam and Dike

Failure analysis was performed for both the dam and dike. Each has a separate impact area.

Dam

Assuming the dam failed with the water level at elevation 770.5 (top of dam), the resulting discharge (based upon Corps Guidelines) would be 216,530 cfs. This assumes forty percent of the 450 foot long (measured at mid-height), 80 feet high dam failed. This discharge and the substantial amount of development downstream indicates a high potential for loss of a significant number of lives. Flood stage at Falulah Reservoir would be 18 feet. Falulah Reservoir would be destroyed. Between Falulah Reservoir and Rindge Road, about 4,000 feet downstream, flood stages would vary between 17 to 24 feet. Due to the steep slope of the outlet brook, elevations of most homes are above the brook elevation. However, several homes and the power station are not and would experience flood damage due to spillway discharge prior to dam failure. All homes, about 17, along Rindge Road and the power sub-station would be destroyed by the dam failure outflow.

Between Rindge Road and Greenes Pond, flood stage would be 15 to 17 feet. In this area, several homes may be damaged by spillway discharge floodwater, prior to dam failure, as they are situated close to the brook. Near Fisher Road, all homes, about 17, would be destroyed by dam failure outflow.

Along Ashby State Road all structures, about 13 homes and several commercial buildings, would be destroyed by dam failure outflow. Flood stage would be about 15 feet. Ashby State Road will

cause a backwater condition at Greenes Pond. Homes and structures in this area are situated above the level of Greenes Pond. Spillway discharge, prior to dam failure should not cause damage in this area.

Spillway discharge prior to failure will cause some flooding damage. Dam failure outflow could destroy all structures within the impact area. Beyond the area studied, additional damage and loss of life will occur until the remaining 54,200 cfs outflow is dissapated within the brook channel.

Dike

Assuming the dike failed with the water level at elevation 770.5, the resulting discharge (based upon Corps Guidelines) woud be 15,400 cfs. This assumes forty percent of a 300 foot long section of the 18 foot high dike fails. The failure impact area considered, extends about 4000 feet along the east side of Rindge Road to Greenes Pond. Flood stage varies from four to twelve feet deep. There is no flooding damage prior to the assumed failure. At least seven homes and two roads are flooded. The potential for loss of many lives is high. Beyond the Greenes Pond area, additional flood damage and loss of life could occur.

SECTION 6

EVALUATION OF STRUCTURAL STABILITY

6.1 Structural Stability

a. Visual Observation

The visual examination of the dam indicates the following potential structural problems:

1. The presence of seepage at the abutment contracts and along the downstream face may, if not controlled, lead to failure of the dam.
2. Erosion features on the downstream face, if left unrepaired, could continue to deepen and lead to serious surface slumping.

The visual examination of the dike indicates the folling potential structural problems:

1. Roots of trees growing on the downstream face could create seepage paths which could lead to internal erosion of the embankment.
2. The poor condition of the riprap in two locations on the dike could result in erosion of the embankment during periods of high wave activity.

A dense cover of vegetation on the downstream slope makes it impossible to inspect the dike and downstream toe area adequately.

b. Design and Construction Data

Construction drawings indicate that the main dam and dike consit of an earth embankment with a reinforced concrete core wall which was keyed into bedrock. The dam embankment was generally

constructed of rolled earth and rockfill. Records indicate that a zone of "very compact material" was placed in 6 inch lifts upstream of the core wall. Because the embankment was not raised uniformly on both sides of the core, there was concern that construction operations may have produced cracks in the core wall.

A series of about 250 construction photographs of the dam were made available and substantiate the existence of the concrete core wall and the compaction of the fill in thin lifts.

No dike construction information was available.

A 78.5 foot wide spillway was constructed on the right abutment of the dam to channel overflow to Falulah Brook downstream from Falulah Reservoir. A single 30 inch diameter outlet pipe exists from the gatehouse along the base of the dam and branches into two 12 inch pipes at the toe area. These pipes discharge into Falaluh Reservoir and the City water system.

c. Operating Records

Seepage through the downstream face and abutment contacts was first reported in 1931 (within 2 years after reservoir filling). Records also indicate that the spillway channel on the right abutment and part of the adjacent embankment were repaired about 1968. In 1975, an inspection by the Commonwealth of Massachusetts Department of Environmental Quality Engineering (DEQE) rediscovered the above mentioned seepage and a letter to the City from the DEQE recommended that the City employ the services of a Registered Professional Engineer to perform an indepth investigation. A reinspection by the DEQE in 1976 found the same deficiencies which concluded in a letter to the City stating that the dam was unsafe again urging the City to obtain the services of a Registered Professional Engineer.

d. Post-Construction Changes

Recently, sand and gravel fill has been placed over an area downstream of the toe of the embankment to cover some wet areas formed by seepage collection.

e. Seismic Stability

The dam and dike are located in Seismic Zone 2 and according to U.S. Corps of Engineers quidelines normally it would be assumed that there is no hazard from earthquake loading provided static stability conditions are satisfactory and conventional safety margins exist. However, because the dam relies on a thin concrete core wall as a water barrier and seepage is existing the downstream slope of the embankment, it is recommended that the owner engage a knowledgeable Registered Professional Engineer to evaluate the possibility of the occurrence of damage to the core wall during earthquate shaking.

SECTION 7

ASSESSMENT, RECOMMENDATION AND REMEDIAL MEASURES

7.1 Dam and Dike Assessment

a. Condition

The visual examination indicates the dam is in fair condition. The major concern is that there are significant areas of seepage on the dam which, if not controlled, could lead to internal erosion and failure of the dam.

On the basis of visual examination, the dike is judged to be in fair condition. The major concerns are:

1. Dense vegetation preventing an adequate inspection of the downstream slope.
2. Presence of numerous trees on the downstream slope. The root systems of these trees could provide shortened seepage paths leading to internal erosion of the dike.
3. Two areas on the upstream slope are not adequately protected by riprap.

b. Adequacy of Information

The information made available, along with the visual inspection, are adequate for a Phase I investigation.

c. Urgency

The recommendations and remedial measures should be implemented within one year after receipt of this Phase I Report by the owner.

d. Need for Additional Investigation

No additional investigation is needed to complete the Phase I inspection.

7.2 Recommendations

It is recommended that the owner engage a qualified registered professional engineer to:

1. Investigate the seepage conditions in the dam embankment and design remedial measures if needed.
2. Evaluate the effect of earthquake shaking on the integrity of the concrete core wall in the dam.
3. Specify procedures for removal of trees and their root systems from the downstream slope of the dike.
4. Design remedial measures for riprap slope protection on the upstream slope of the dike.
5. Perform an indepth hydraulic/hydrologic study of the dam site to determine the adequacy of the spillway and outlet channel and if necessary, to design modifications to the existing spillway and outlet channel.

7.3 Remedial Measures

a. Operation and Maintenance Procedures

1. Substantial growths of trees and brush at the dam were reported in previous State Inspection Reports, and were removed in 1977 and 1978. Upstream and downstream slopes of the main dam and dike should be maintained free of brush and tree growth.
2. Grass cover should be maintained at a reasonable height to permit inspection of slopes to detect possible problems.

3. Trees and brush should be removed from the spillway outlet channel bottom and slopes adjacent to channel walls. These areas, should be maintained free of tree and brush growth.
4. All valves for water supply inlet and outlet pipes should be tested regularly to insure they are operable. Inoperable valves should be repaired.
5. Areas where animal burrowing has occured should be properly backfilled with compacted fill.
6. The erosion gullies located where the downstream stone-paved drainage bench interfaces the left abutment and the erosion gullies on the right abutment contact should be repaired using compacted gravel. The same repair should also be applied to the erosive gullies located on the upstream face adjacent to the spillway training wall.
7. Although the downstream masonry falls has no affect on the safety of the dam, the erosion features should be repaired.
8. The owner should establish a formal warning system to notify downstream areas in the event of an emergency. Around the clock monitoring of the facility should be provided during periods of heavy rainfall.
9. The owner should institute a program of annual technical inspection.

7.4 Alternatives

There are no practicle alternatives for this project.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECKLIST
PARTY ORGANIZATION

PROJECT Lovell Reservoir

DATE April 11, 1979

TIME 1:30 PM

WEATHER 60°F, Clear

W.S. ELEV. 764.1+ U.S. 760.1± N.S.

PARTY:

1. Ron Cheney HHB
2. Dave Vine HHB
3. Mike Angieri HHB
4. Dan LaGatta GEI
5. John France GEI
6. Bob Stekar GEI
7. Maurice Caron Fitchburg Water Dept.
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Spillway - Outlet works	Ron Cheney, Mike Angieri, David Vine	
2.	Intake Structure	Ron Cheney, Mike Angieri, David Vine	
3.	Embankment Dam	Dan LaGatta, John France, Bob Stekar	
4.	Dike *	Dan LaGatta, Ron Cheney, David Vine	
5.			
6.			
7.			
8.			
9.			
10.			

* Inspected June 17, 1980

PERIODIC INSPECTION CHECKLIST

PROJECT LOVELL RESERVOIR DAM — DATE April 11, 1979

PROJECT FEATURE Embankment Dam — NAME D. LaGatta, J. France

DISCIPLINE Geotechnical Engineer — NAME R. Stetkar

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	770.5 ±
Current Pool Elevation	764 ±
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed.
Pavement Condition	None. Sand and gravel road on crest.
Movement or Settlement of Crest	None observed.
Lateral Movement	None observed.
Vertical Alignment	No observable misalignment.
Horizontal Alignment	No observable misalignment.
Condition at Abutment and at Concrete Structures	Good.
Indications of Movement of Structural Items on Slopes	No structural items on slopes.
Trespassing on Slopes	Some small animal holes.
Sloughing or Erosion of Slopes or Abutments	No evidence of sloughing. Slight wave erosion on upstream face near spillway on right abutment. Erosion on downstream face at left abutment contact below drainage bench.
Rock Slope Protection - Riprap Failures	Upstream riprap in good condition but only 1 ft above reservoir level. No riprap on downstream face.
Unusual Movement or Cracking at or Near Toe	None observed.
Unusual Embankment or Downstream Seepage	Seepage exits from right abutment contact and from left abutment up to 65 ft downstream from toe of dam.
Piping or Boils	Surface of seepage exits through downstream face 15 ft above toe of dam
Foundation Drainage Features -	None observed.
Toe Drains	Possible toe drain into Falulah Reservoir
Instrumentation System	None.
Vegetation	Small brush on downstream slope.

PERIODIC INSPECTION CHECKLIST

PROJECT LOVELL RESERVOIR DIKE DATE June 17, 1980

PROJECT FEATURE Embankment Dike NAME D. LaGatta

DISCIPLINE Geotechnical Engineer NAME R. Cheney
Structural Engineer

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	Embankment dike with concrete core wall.
Crest Elevation	770.5±
Current Pool Elevation	762±
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed.
Pavement Condition	No pavement.
Movement or Settlement of Crest	None observed.
Lateral Movement	No misalignment observed.
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	Right abutment contacts main dam. Condition good at both abutments.
Indications of Movement of Structural Items on Slopes	No structures on slope.
Trespassing on Slopes	None.
Sloughing or Erosion of Slopes or Abutments	None. See note below re: riprap.
Rock Slope Protection - Riprap Failures	There is a slump in riprap. See text.
Unusual Movement or Cracking at or Near Toes	None observed.
Unusual Embankment or Downstream Seepage	None observed.
Piping or Boils	None observed.
Foundation Drainage Features	None.
Toe Drains	None.
Instrumentation System	None.
Vegetation	Dense vegetation on both slopes.

PERIODIC INSPECTION CHECK LIST

PROJECT Lovell Reservoir DATE April 11, 1979

PROJECT FEATURE Intake Structure NAME Ron Cheney

DISCIPLINE Structural Engineer NAME Daniel P. LaGatta
Geotechnical Engineer

AREA EVALUATED	CONDITIONS
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	No intake channel
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	
Condition of Concrete	Visible portion good
Stop Logs and Slots	None
	3 gate valves for control of water at dam inside intake structure, according to Water Department personnel, the bottom 30" valve is broken and all valves are in the open position.

PERIODIC INSPECTION CHECK LIST

PROJECT Lovell Reservoir DATE April 11, 1979

PROJECT FEATURE Outlet Tower NAME Ron Cheney

DISCIPLINE Structural Engineer NAME Daniel P. LaGatta
Geotechnical Engineer

AREA EVALUATED	CONDITIONS
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	
General Condition	
Condition of Joints	
Spalling	Intake structure and control tower are one and the same
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	None - all controls are manual
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System in Gate Chamber	

PERIODIC INSPECTION CHECK LIST

PROJECT Lovell Reservoir DATE April 11, 1979

PROJECT FEATURE Outlet Channel NAME Ron Cheney

DISCIPLINE Structural Engineer NAME Daniel P. LaGatta
Geotechnical Engineer

AREA EVALUATED	CONDITIONS
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	No outlet structure.
Rust or Staining	
Spalling	
Erosion or Cavitation	
Visible Reinforcing	
Any Seepage or Efflorescence	
Condition at Joints	
Drain Holes	
Channel	No outlet channel. 30 inch diameter outlet pipe to Falulah Reservoir and water supply system.
Loose Rock or Trees Overhanging Channel	
Condition of Discharge Channel	

PERIODIC INSPECTION CHECK LIST

PROJECT Lovell Reservoir DATE April 11, 1979

PROJECT FEATURE Transition & Conduit NAME Don Cheney

DISCIPLINE Structural Engineer NAME Daniel P. LaGatta

Geotechnical Engineer

AREA EVALUATED	CONDITIONS
OUTLET WORKS - TRANSITION AND CONDUIT	None
General Condition of Concrete	
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECK LIST

PROJECT Lovell Reservoir DATE April 11, 1979

PROJECT FEATURE Spillway NAME Ron Cheney

DISCIPLINE Structural Engineer NAME Daniel P. LaGatta
Geotechnical Engineer

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	Underwater during inspection appeared good.
General Condition	
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Numerous 2" to 6" on slopes
Floor of Approach Channel	Stone lined, appeared in good condition
b. Weir and Training Walls	
General Condition of Concrete	Good
Rust or Staining	Some on walls
Spalling	Could not detect - water flowing over crest
Any Visible Reinforcing	None observed
Any Seepage or Efflorescence	Some
Drain Holes	Several in concrete walls
c. Discharge Channel	
General Condition	Fair (450' long) brush & trees in channel.
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Numerous 2" to 6" on slopes
Floor of Channel	Stone lined-erosion upstream of falls-see text
Other Obstructions	Trees (1" to 2") in channel at end of concrete/stone channel, water fall 10-12 feet high, then channel excavated into natural soil some areas have stone walls.

PERIODIC INSPECTION CHECK LIST

PROJECT Lovell Reservoir DATE April 11, 1979

PROJECT FEATURE Service Bridge NAME Ron Cheney

DISCIPLINE Structural Engineer NAME Daniel P. LaGatta
Geotechnical Engineer

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SERVICE BRIDGE	
a. Super Structure	None
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Under Side of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment and Piers	None
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat and Backwall	

APPENDIX B

ENGINEERING DATA

LIST OF ENGINEERING DATA

1. Construction Plans available at:

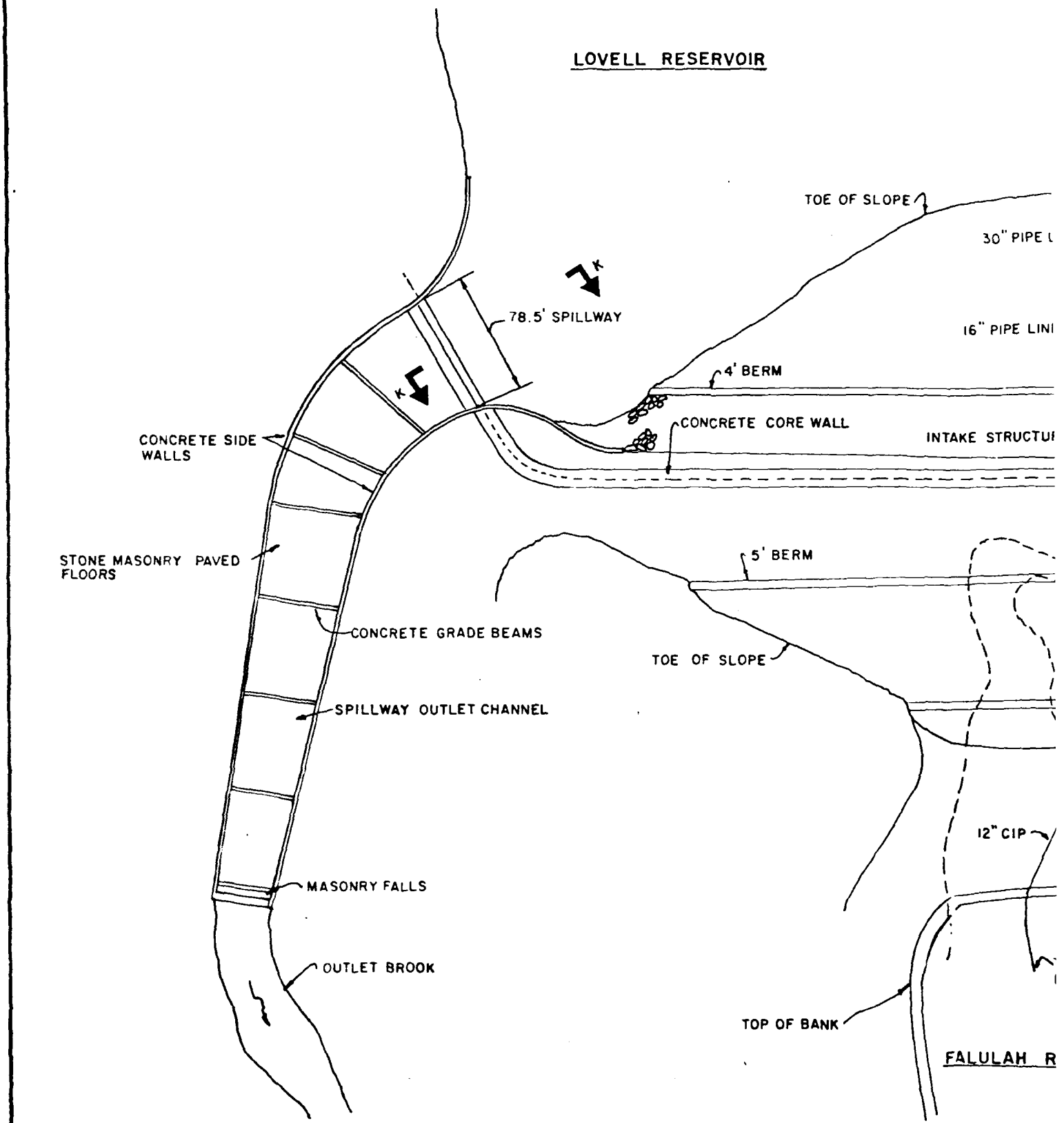
a. Worcester County Court House Engineering Department
b. City of Fitchburg Engineering Department

2. Construction Inspection Reports available at:

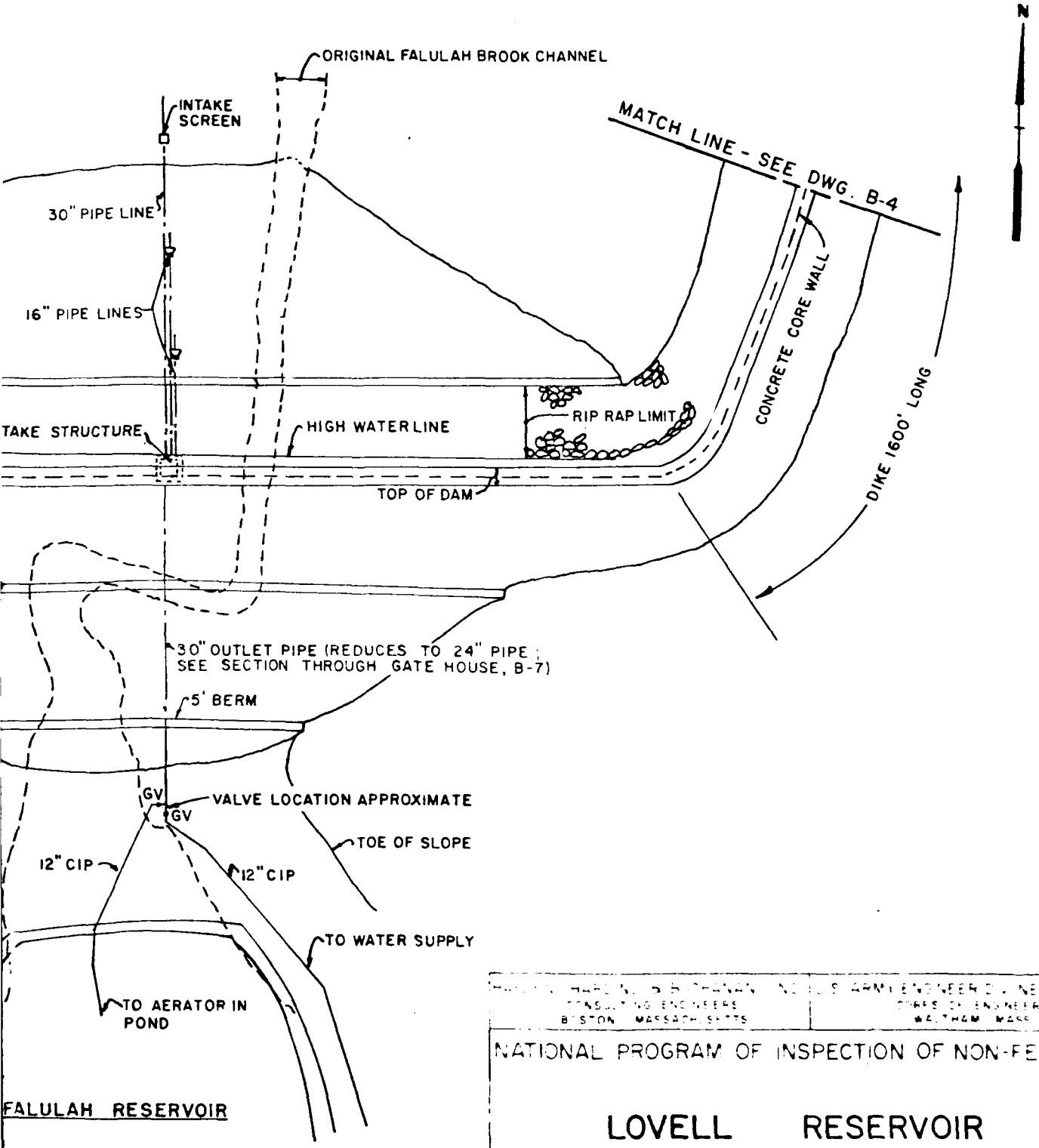
Worcester County Court House Engineering Department

3. Post Construction Inspection Reports available at:

a. Worcester County Court House Engineering Department
b. Department of Environmental Quality Engineering, Division of Waterways, 100 Nashua Street, Boston, Massachusetts 02104


LOVELL RESERVOIR
TOE OF SLOPE
30" PIPE L
K
78.5' SPILLWAY
16" PIPE LINI
4' BERM
K
CONCRETE CORE WALL
CONCRETE SIDE WALLS
INTAKE STRUCTUI
5' BERM
STONE MASONRY PAVED FLOORS
CONCRETE GRADE BEAMS
TOE OF SLOPE
SPILLWAY OUTLET CHANNEL
12" CIP
MASONRY FALLS
OUTLET BROOK
TOP OF BANK
FALULAH R

PLAN VIEW



PLAN DEVELOPED FROM RECORD DRAWINGS AND ON-SITE INSPECTION.

CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

U.S. ARMY ENGINEER DIV. NEW ENG. AREA
CORPS OF ENGINEERS
WALTHAM MASS.

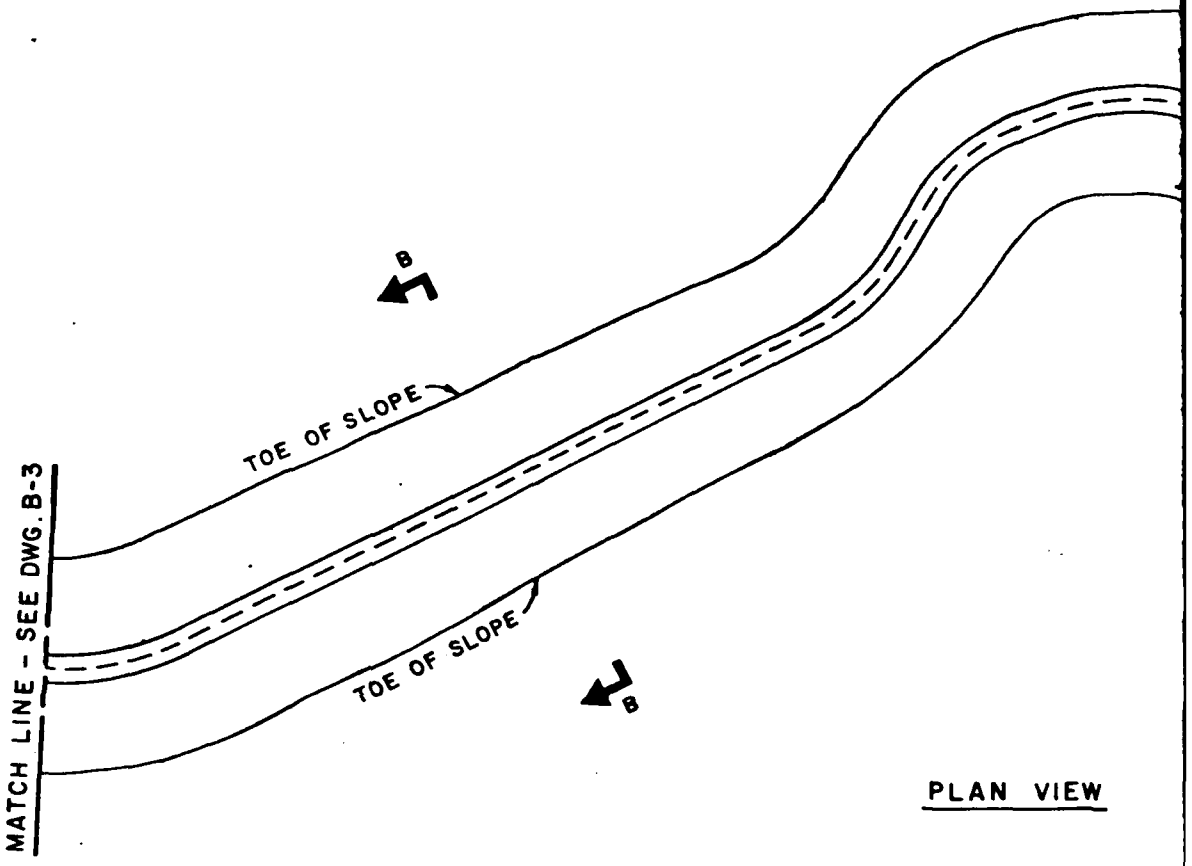
NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

LOVELL RESERVOIR DAM & DIKE

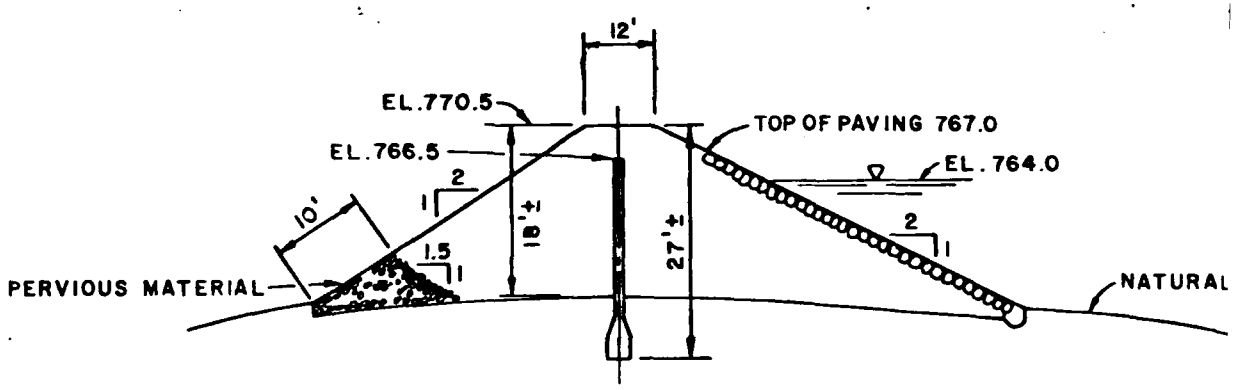
FITCHBURG MASSACHUSETTS

SCALE AS NOTED

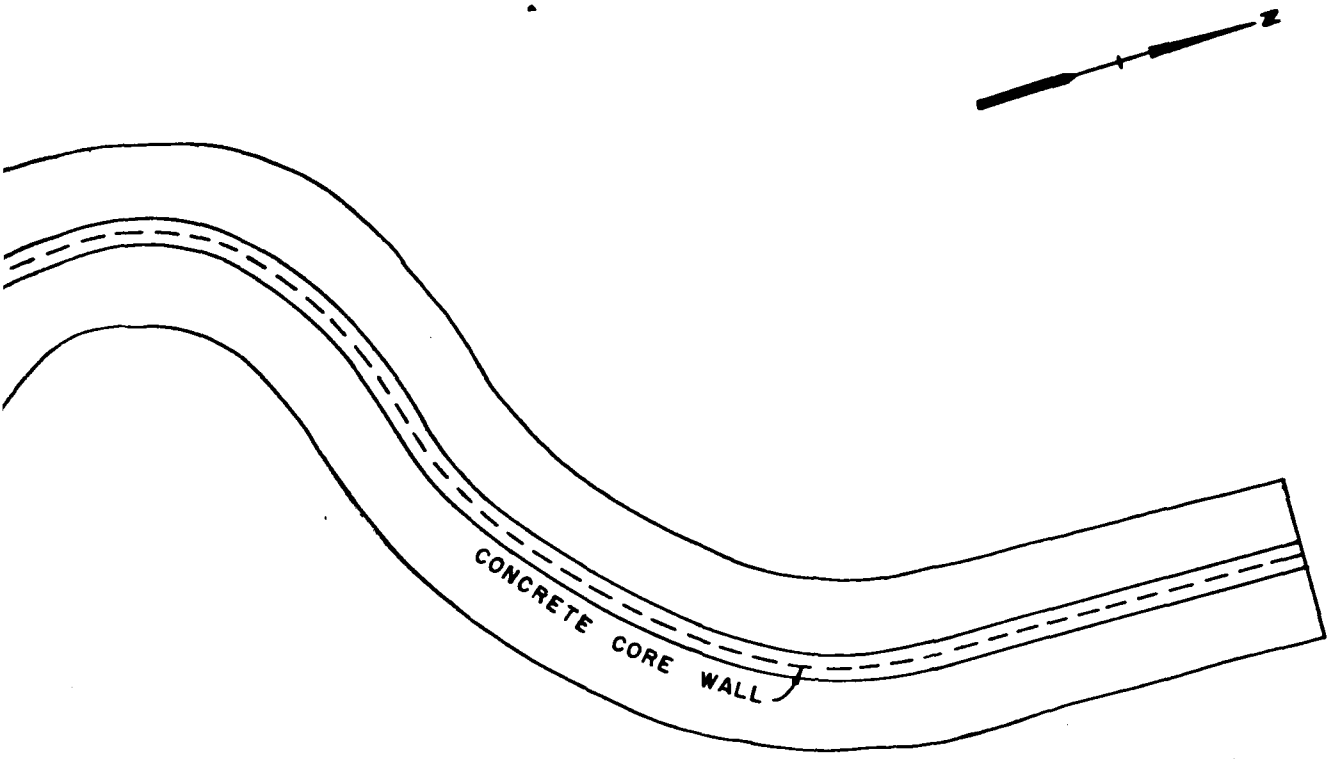
DATE JUNE, 1979



PLAN VIEW



SECTION B-B



N VIEW

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NATURAL SURFACE

PLAN DEVELOPED FROM RECORD DRAWINGS AND ON-SITE INSPECTION.

HAYDEN, HARDING & BUCHANAN, INC. CONSULTING ENGINEERS BOSTON, MASSACHUSETTS	U.S. ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

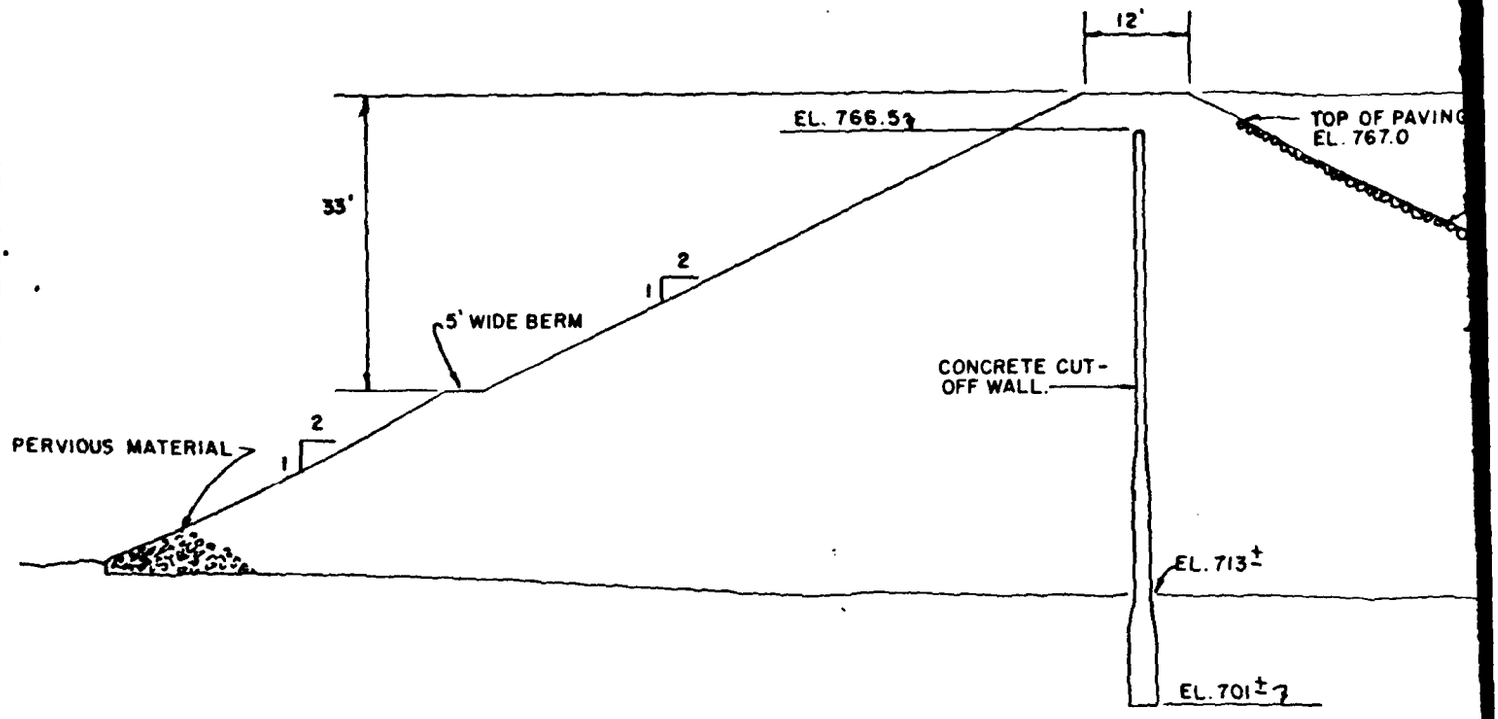
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOVELL RESERVOIR DIKE

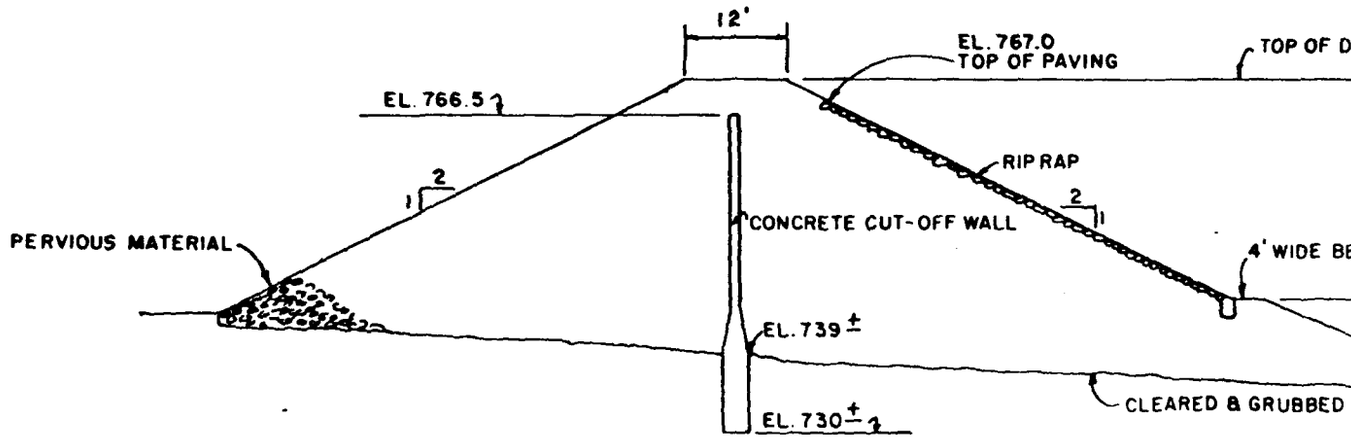
FITCHBURG MASSACHUSETTS

SCALE NOT TO SCALE

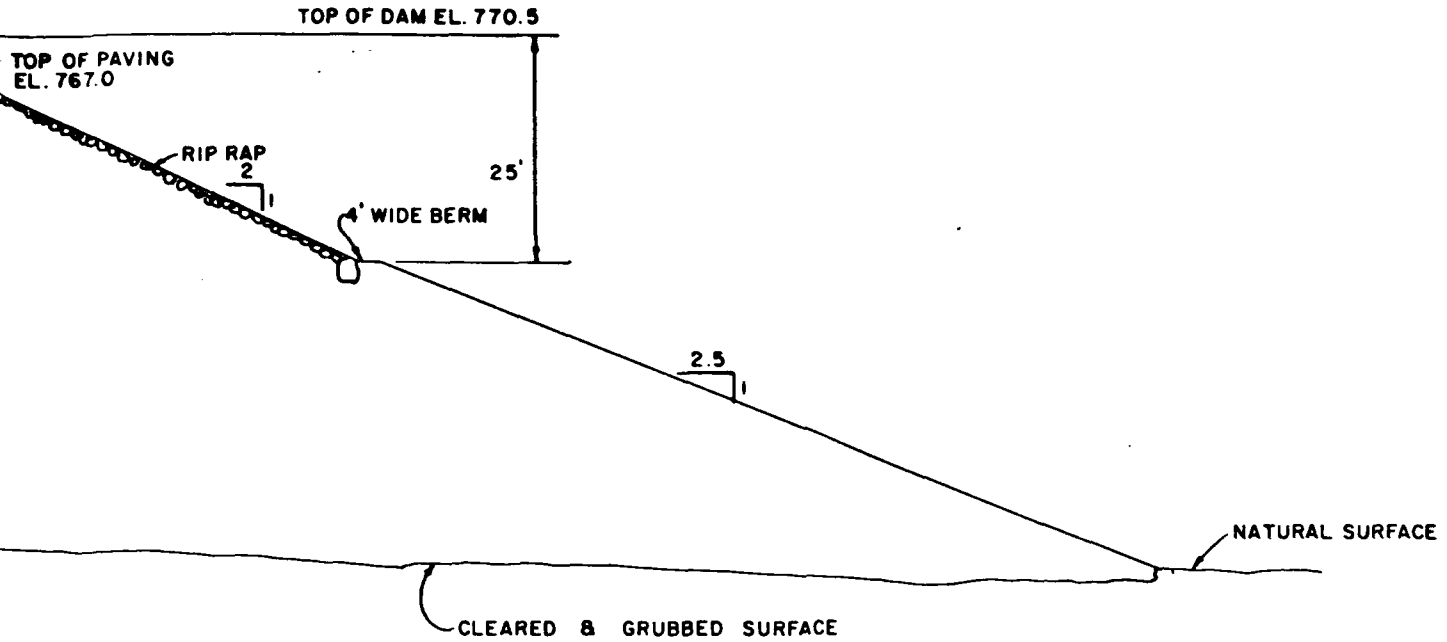
DATE JULY, 1980



SECTION AT STA. 2+00



SECTION AT STA. 1+00



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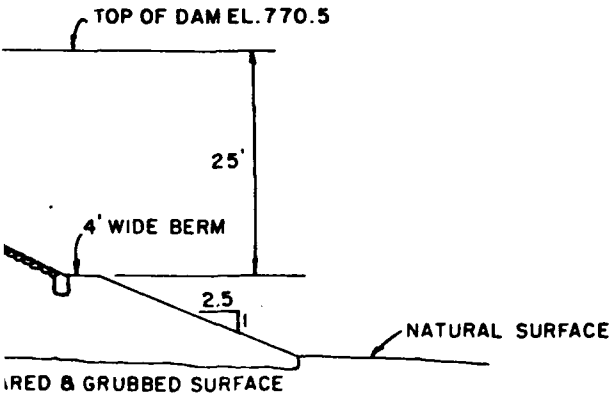


SECTIONS TAKEN FROM RECORD PLANS, APRIL 1927.

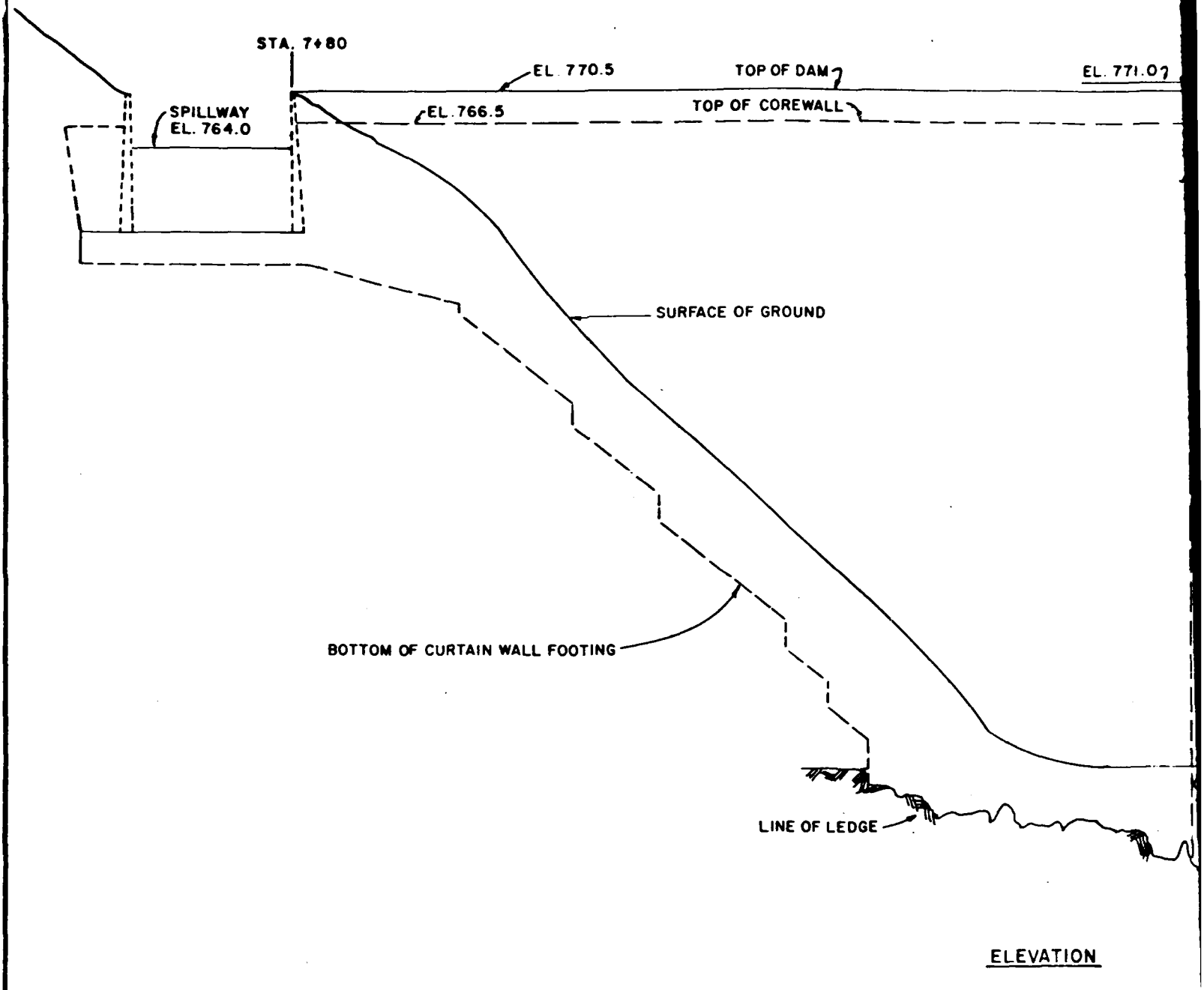
HAYDEN, HARDING & BUCHANAN, INC CONSULTING ENGINEERS BOSTON, MASSACHUSETTS	U S ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOVELL RESERVOIR DAM

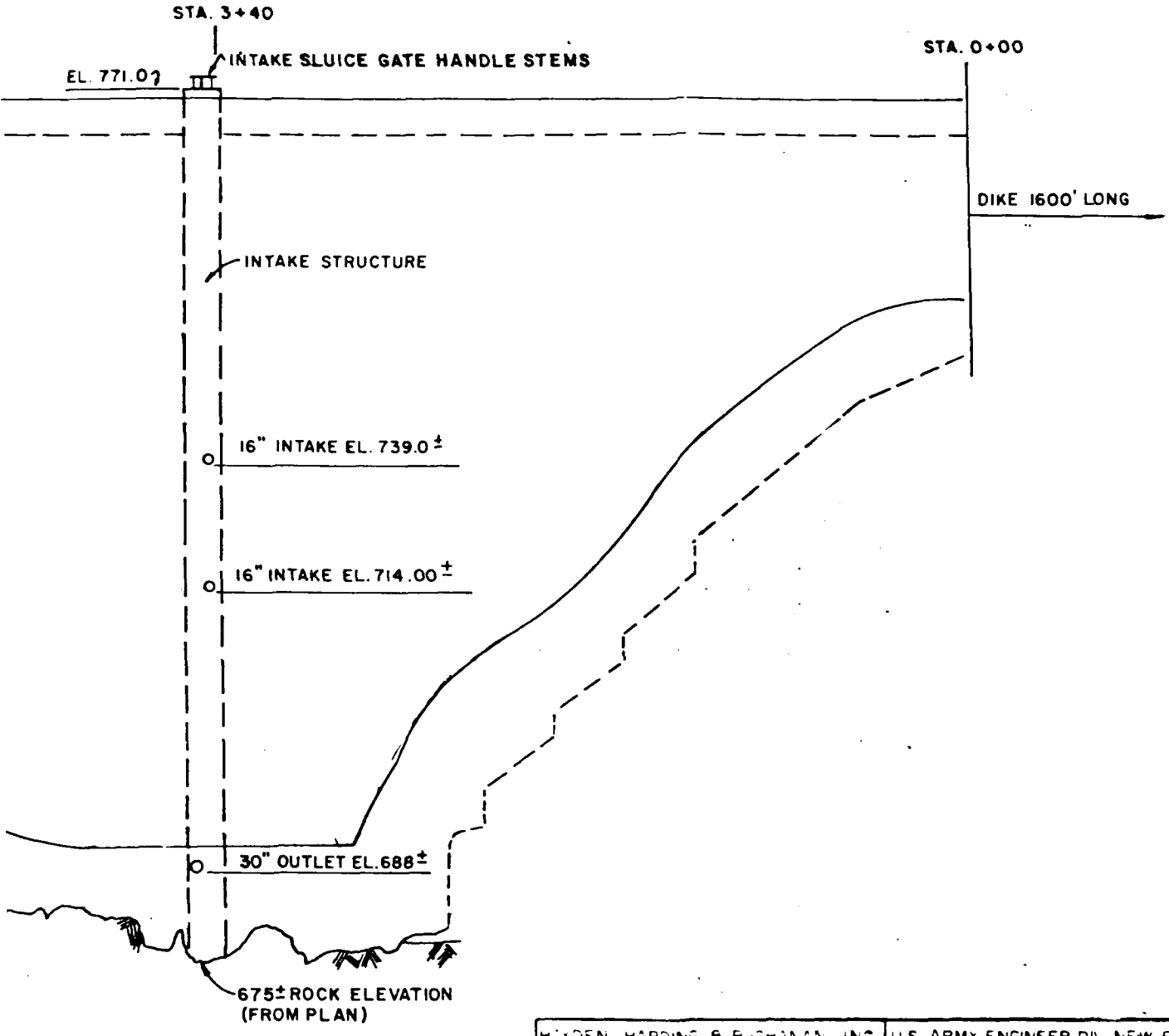
FITCHBURG MASSACHUSETTS

			SCALE NOT TO SCALE
			DATE JUNE, 1979



ELEVATION

ELEVA
PLANS



VATION

ELEVATION TAKEN FROM RECORD PLANS DATED APRIL 1927.

HAYDEN, HARDING & BUCHANAN, INC CONSULTING ENGINEERS BOSTON, MASSACHUSETTS	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS

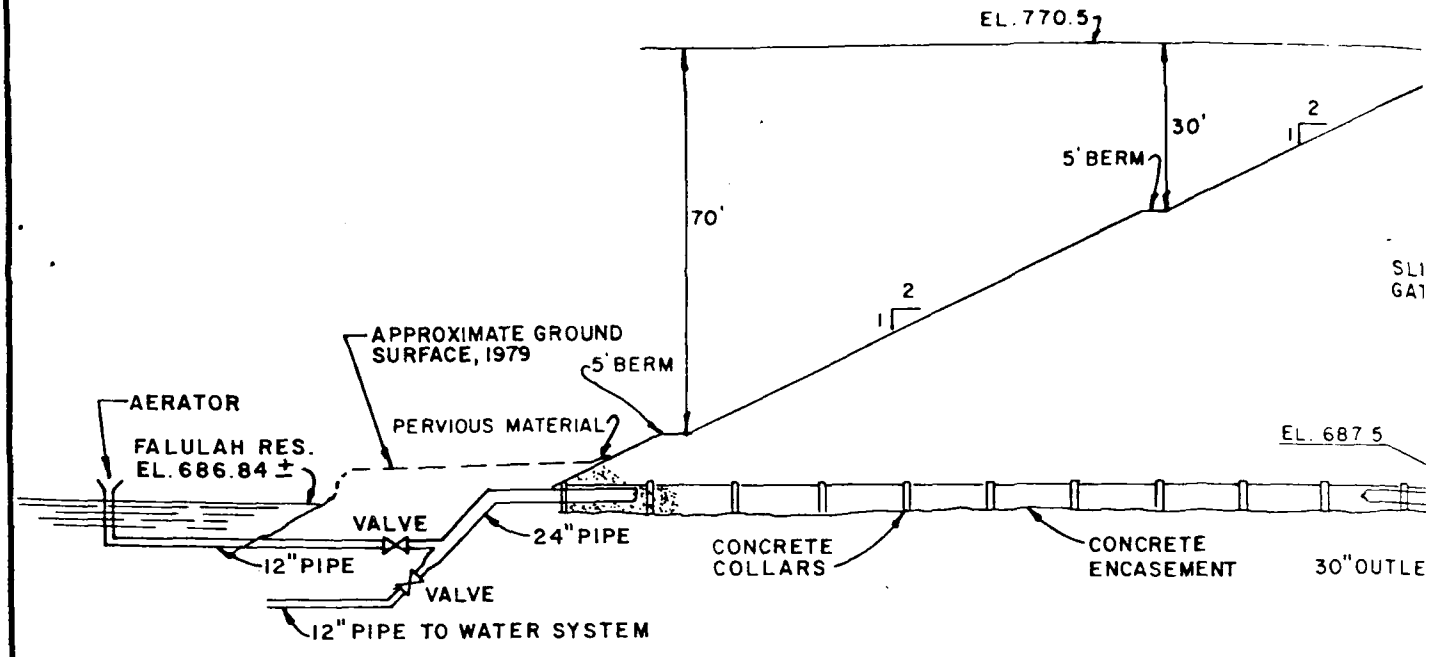
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOVELL RESERVOIR DAM

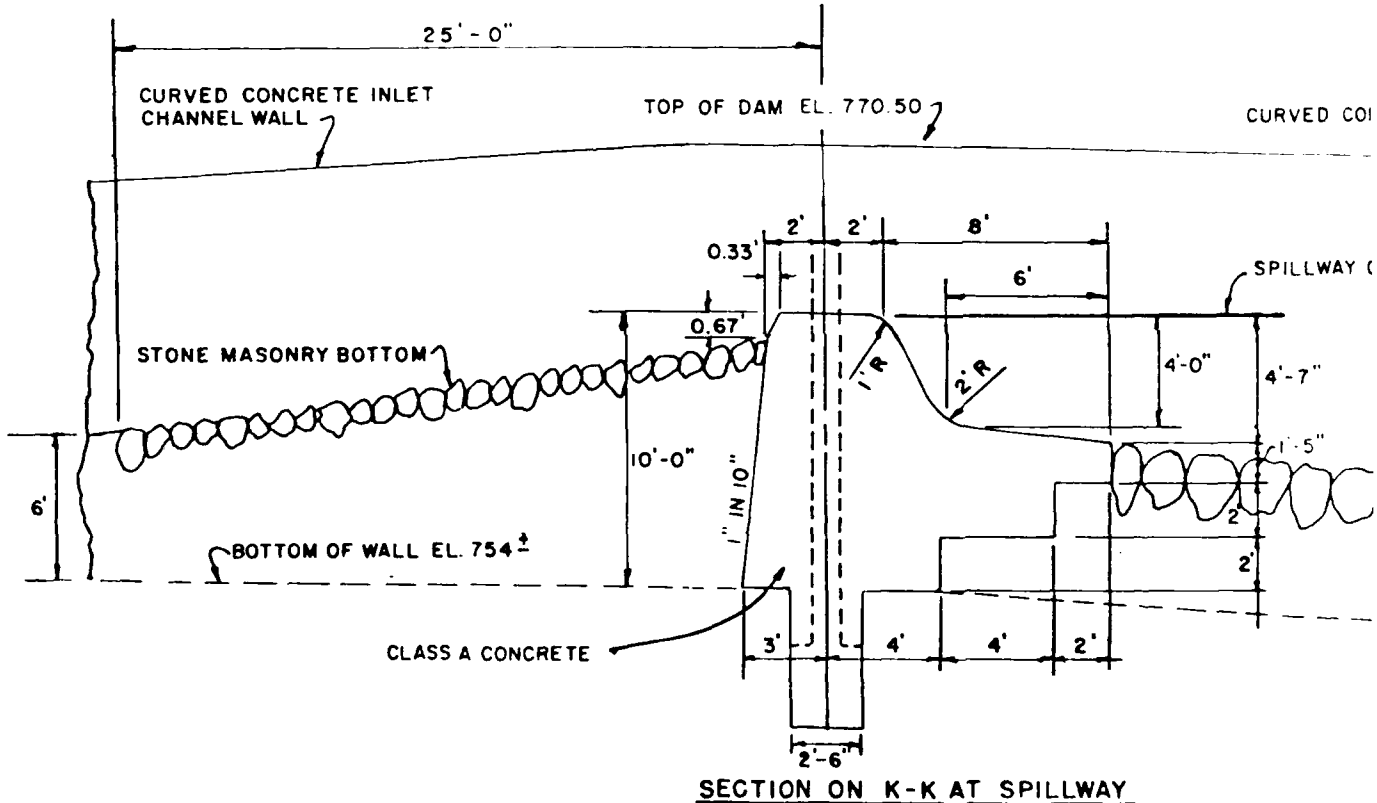
FITCHBURG MASSACHUSETTS

SCALE NOT TO SCALE

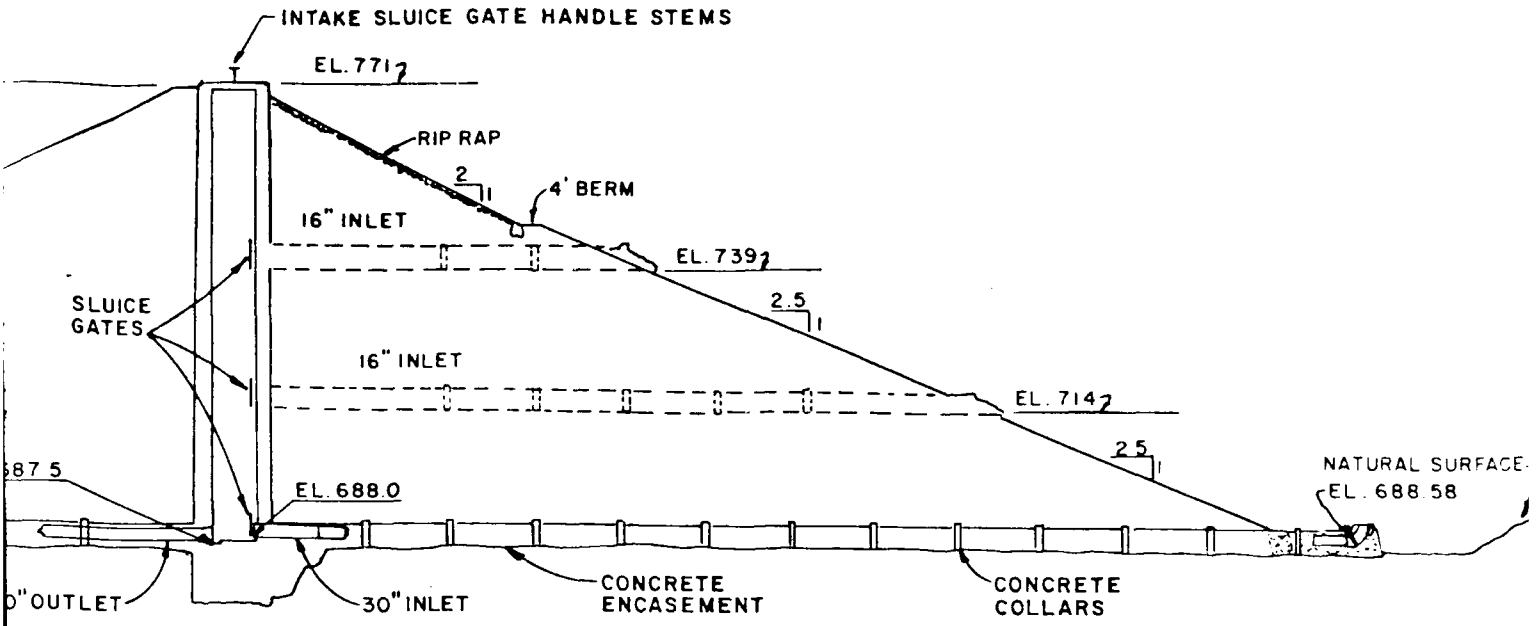
DATE JUNE, 1979



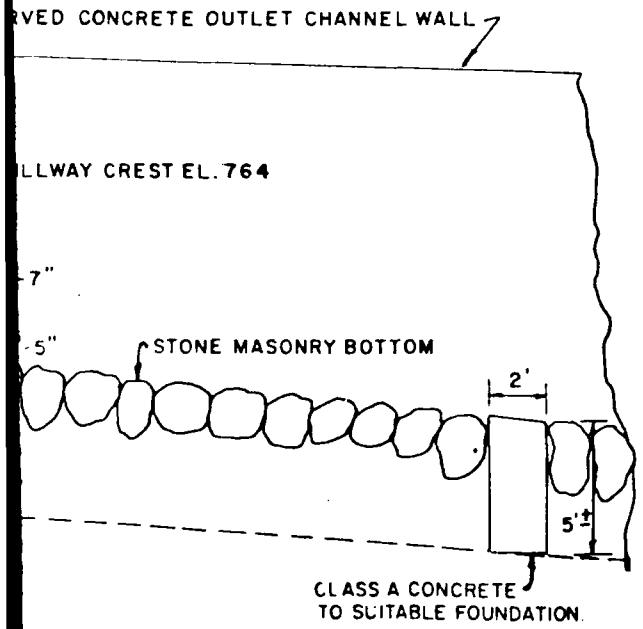
SECTION THROUGH



SECTION ON K-K AT SPILLWAY



ROUGH GATE HOUSE AT STA 3+50



SECTIONS TAKEN FROM RECORD PLAN, APRIL 1929 & ON-SITE INSPECTION.

HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON, MASSACHUSETTS

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

LOVELL RESERVOIR DAM

FITCHBURG MASSACHUSETTS

SCALE NOT TO SCALE

DATE JUNE, 1979

The Commonwealth of Massachusetts

EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGR.
DIVISION OF WATERWAYS

100 Nashua Street, Boston 02114

February 24, 1977

The Honorable Hedley Bray
Mayor, City of Fitchburg
City Hall
718 Main Street
Fitchburg, Mass.

RE: Letters dated 2.10.77
Insp. Dams #3-14-97.28.1 Overlook Reser. Dam
" " #3-14-97-34 Lovell Reserv. Dam
" " #3-14-97-28 Overlook Reser. (So. Dyke)
" " #3-14-97-37 Scott Reser. Dam

Fitchburg, Mass.

Dear Mayor Bray:

On June 10, 1976, an Engineer from Mass. Department of Public Works made an inspection of the above dams. Our records indicate the owner to be the City of Fitchburg. As a result of these inspections this Division has rated these structures unsafe and has duly notified you of their condition (ltrs. dated 2.10.77 .

We again urge you to obtain the services of a Registered Professional Engineer, experienced in the design, maintenance and construction of dams in order that you may pursue remedy as quickly as possible.

Enclosed is a Department application form which must be completed and returned to this office for review and approval before any major repairs or alterations begin.

Please notify this Division of your intentions or measures in process which will correct this situation.

If we may be of assistance, do not hesitate to contact us. With any correspondence, please include the number of the dam as indicated above.

Very truly yours,

JOHN J. HANNON, P.E.
CHIEF ENGINEER

F.DeR.:eh
CC: D.H.E. DIST. #3
D.D.E. " #3
Ernie Giroud, Commr. D.P.W.

The Commonwealth of Massachusetts

EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL QUALITY ENGR.
DIVISION OF WATERWAYS

100 Nashua Street, Boston 02114

The Honorable Hedley Bray, Mayor
City Hall
718 Main Street
Fitchburg, Ma.

Re: Inspection Dam #3-14-97-34
Lowell Reservoir Dam
Fitchburg, Ma.

Dear Sir:

On June 10, 1976, an Engineer from the Massachusetts Department of Public Works made a visual inpsection of the above dam. Our records indicate the owner to be the City of Fitchburg If this information is incorrect will you please notify this office.

The inspection was made in accordance with the provisions of Chapter 253 of the Massachusetts General Laws as amended (Dams Safety Act). Chapter 706 of the Acts of 1975 transferred the jurisdiction o the so-called (Dams Safety Program) to the Commissioner of the Depart ment of Environmental Quality Engineering.

The results of the inspection indicate that this Dam is unsafe

We urge you to obtain the services of a Registered Professional Civil Engineer experienced in the design, maintenance and constructio of dams. Enclosed is a Department application form which must be completed and returned to this office for review and approval before any major repairs or alterations begin.

If we may be of assistance, do not hesitate to contact us. With any correspondence, please include the number of the dam as indicated above.

Very truly yours,

JOHN J. HANNON, P.E.
CHIEF ENGINEER

A.J.C.
cc: District Highway Eng., Dist 3
District Dam & Reservoir Eng. Dist. 3
Ernie Giroud, Commissioner of Public Works
File

12-30-77

The Commonwealth of Massachusetts

Executive Office of Environmental Affairs

Department of Environmental Quality Engineering

Division of Waterways

100 Nashua Street, Boston 02114

December 21, 1977

Refer Ernest Dion

The Honorable Hedley Bray, Mayor
City of Fitchburg
City Hall
718 Main Street
Fitchburg, Mass.

RE: Dam #3-14-97-28 Overlook Reservoir (So. Dyke)
Dam #3-14-97-28.1 Overlook Reservoir Dam
Dam #3-14-97-34 Lovell Reservoir Dam
Dam #3-14-97-37 Scott Reservoir Dam

Dear Mayor Bray:

On February 10 and 24, 1977 you were notified of the unsafe condition of the above referenced dams. You were urged on both occasions to obtain the services of a Registered Professional Engineer. (RPE)

Please advise me by January 6, 1978 the name(s) of the RPE(s) the City has retained to oversee the rehabilitation of these structures.

Provided herewith is a copy of Chapter 253 Sections 44-49 inclusive as amended by Chapter 706 of 1975 of the Massachusetts General Laws that define our jurisdiction and authority should any order not be complied with.

If you have any questions or need assistance in this matter please contact me in Boston.

Sincerely,

For the Commissioner

JOHN J. HANNON, P.E.
CHIEF ENGINEER

EHM:bjm
Encl.
CC: David Standley, Comm.
Gilbert Joly, REE
John J. Lyons, DHE
Willis Regan, Dist. #3
Al McCallum

PUBLIC WORKS DEPT. FITCHBURG, MASS.
DEC 30 11 27 AM '77

DEC 3 1977

B-10

INSPECTION REPORT - DAMS AND RESERVOIRS

1. Location: City/~~Town~~ Fitchburg Dam No. 3-14-97-34

Name of Dam LOVELL RESERVOIR Inspected by REGAN, RIZKALL

Date of Inspection 6/10/76

2. Owner/s: per: Assessors _____ Prev. Inspection ✓

Reg. of Deeds _____ Pers. Contact _____

1. The Hon Hedley Bray. MAYOR - City HALL - 718 MAIN St. Fitchburg
Name COPY TO St. & No. City/Town State Tel. No.

2. Ernie Girourd. Comm. of Public Works - City Hall
Name St. & No. City/Town State Tel, No.

3. _____
Name St. & No. City/Town State Tel. No.

3. Caretaker (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Name: St. & No.:

City/Town: State: Tel.No.:

4. No. of Pictures taken _____

5. Degree of Hazard: (if dam should fail completely)*

1. Minor _____ 2. Moderate _____

3. Severe ✓ _____ 4. Disastrous _____

* This rating may change as land use changes (future development)

6. Outlet Control: Automatic _____ Manual ✓

Operative ✓ yes; _____ No.

Comments: Gated main to Lower Pool (FALULAH Reservoir)

7. Upstream Face of Dam: Condition:

1. Good _____ 2. Minor Repairs ✓

3. Major Repairs ___ 4. Urgent Repairs ___

orComments: Remove Brush (both MAIN & Secondary Dikes)

DAM NO. 3-14-97-34

8. Downstream Face of Dam:

Condition: 1. Good _____ 2. Minor Repairs _____

3. Major Repairs ✓ 4. Urgent Repairs _____

Comments: Remove heavy brush - main Dike, remove heavy Growth Trees & brush - Secondary dike for remarks on leakage - See(12)

9. Emergency Spillway:

Condition: 1. Good _____ 2. Minor Repairs _____

3. Major Repairs ✓ 4. Urgent Repairs _____

Comments: Very heavy Growth of ~~Weed~~ Brush in Spillway Severe deterioration of Spillway floor 456'± d.s. of Entrance Noted in '75 Report Remains uncorrected & has Progressed.

10. Water Level at time of inspection: 9 ± ft. above ____ below ✓

top of dam Emb. ____ principal spillway ____

other 70'± Above Downstream Toe.

11. Summary of Deficiencies Noted:

Growth (Trees and Brush) on Embankment Very heavy

Animal Burrows and Washouts (See 12)

Damage to slopes or top of dam —

Cracked or Damaged Masonry ✓

Evidence of Seepage ✓ Moderate To Heavy

Evidence of Piping (See 12)

Erosion —

Leaks ✓

Trash and/or debis impeding flow —

Clogged or blocked spillway Very heavy growth of SMALL Trees & Brush IN SPILLWAY

Other _____

12. Remarks & Recommendations: (Fully Explain)

None of the deficiencies noted in the 4/25/75 Report have been corrected. The leakage noted at the time of this ('75) INSPECTION appeared to be heavier THAN THAT NOW Noted (6/10/76) and the Pools of Standing water at the d.s. Toe of the Secondary dike are not Now in Evidence. The Elev. of the UPPER Pool IS 1½' – 2' lower than at the time of the '75 INSPECTION and the Growth of Trees and brush on the D.S face IS So heavy that a Thorough INSPECTION is greatly impeded. Therefore Conditions noted in the '75 INSPECTION (piping boil, animal burrow) are INACCESSIBLE To VISUAL INSPECTION but Very Probable REMAIN.

13. Overall Condition: – Should be determined by an independent Consultant INSPECTION

1. Safe _____
2. Minor repairs needed _____
3. Conditionally safe – major repairs needed _____
4. Unsafe _____
5. Reservoir impoundment no longer exists (explain)

   Recommend removal from inspection list _____

5-20-75

5-20-75

May 13, 1975

Honorable Hedley Bray
Mayor of Fitchburg
City Hall
718 Main Street
Fitchburg, Massachusetts

RE: Inspection Dam #3-14-97-34
Fitchburg
Lovell Reservoir Dam

Dear Mayor Bray:

On April 25, 1975, an engineer from the Massachusetts Department of Public Works made a visual inspection of the above dam. Our records indicate that the City of Fitchburg is the owner. Will you please notify this office if this information is not current.

The inspection was made in accordance with Chapter 253 of the Massachusetts General Laws, as amended by Chapter 595 of the Acts of 1970 (Dams-Safety Act).

The results of the inspection indicate that repairs are needed. Pending future in-depth investigations to substantiate our findings, the dam could be termed unsafe. The following conditions were noted that require attention:

At the emergency spillway

1. There is considerable growth of trees in the spillway floor which should be removed.

2. A section of the spillway floor of the lower spillway drop at the easterly raceway has failed forming a hole in the slab. Just downstream of this failure water is flowing from a hole in the embankment (size about 12" square flowing about ½ full).

At the easterly dike

1. There are several pools of standing water just beyond the downstream toe about 350 ft. northerly of the intersection of the main and secondary dikes.

2. Trees and brush growth should be removed.

At Main Dike (south side of reservoir)

1. There is substantial seepage through the embankment in spite of the existence of a core wall. If the core wall has failed then the structural integrity of the dam is questionable. It appears that a gravel blanket has been placed at this location due to seepage. Falulah Reservoir is just downstream.

2. There are numerous locations adjacent to the aforementioned gravaled area where water flows. Deltas of silt were noted. One boil was observed.

3. Burrowing animals were observed at the embankment.

This dam has been neglected for a period of time as moderate to critical deterioration is in evidence. It is strongly recommended that you obtain the services of a Registered Professional Civil Engineer experienced in the design, maintenance and construction of dams. An in-depth investigation is required followed by the necessary corrective repairs.

A preliminary reconnaissance of other dams in the Fitchburg Water System indicates the lack of any definative maintenance program. Several appear to have heavy seepage. At least two of these, Scott Reservoir and Lovell Reservoir Dams, will require in-depth consideration. It may be advisable for you to conduct an investigation of all dams. This office will provide more specific comments upon receipt of reports for the other dams.

Due to the safety considerations for life and property downstream, prompt action is necessary. If we may be of assistance, please do not hesitate to contact us. With any correspondence, please include the number of the dam as indicated above.

Very truly yours,

MALCOLM E. GRAF, P.E.
Associate Commissioner

LEA:jmp
cc: A. Provencial, Supt., Fitchburg
J. J. Lyons
W. Regan

INSPECTION REPORT - DAMS AND RESERVOIRS

1. Location: City/~~Town~~ Fitchburg Dam No. 3-14-97-34

Name of Dam Lovell Reservoir Inspected by Regan, Rizkalla

Date of Inspection 4/25/75

2. Owner/s: per: Assessors _____ Prev. Inspection _____

Reg. of Deeds _____ Pers. Contact ✓

1. The Hon. Hedley Bray - Mayor - City Hall - 718 Main St. - Fitchburg, Mass
Name copy To St. & No. City/Town State Tel. No.

2. A. Provencial - Fitch Water Dept. Supt. - Kimball Place - Fitchburg
Name St. & No. City/Town State Tel, No.

3. _____
Name St. & No. City/Town State Tel. No.

3. Caretaker (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Name: St. & No.:

City/Town: State: Tel.No.:

4. No. of Pictures taken _____

5. Degree of Hazard: (if dam should fail completely)*

1. Minor _____ 2. Moderate _____

3. Severe ✓ 4. Disastrous _____

* This rating may change as land use changes (future development)

6. Outlet Control: Automatic _____ Manual ✓

Operative ✓ yes; _____ No.

Comments: Gated main to Lower Pool (Falulah Reservoir)

7. Upstream Face of Dam: Condition:

1. Good _____ 2. Minor Repairs ✓

3. Major Repairs ___ 4. Urgent Repairs ___

Comments: Remove brush (main & Secondary dikes)

DAM NO. 3-14-97-34

8. Downstream Face of Dam:

Condition: 1. Good _____ 2. Minor Repairs _____

3. Major Repairs ✓ 4. Urgent Repairs _____

Comments: Remove Heavy brush main dike, Remove heavy Trees & Brush Secondary dike - Intercept leakage. Through both dikes

9. Emergency Spillway:

Condition: 1. Good _____ 2. Minor Repairs _____

3. Major Repairs ✓ 4. Urgent Repairs _____

Comments:

10. Water Level at time of inspection: 7.3± ft. above ____ below ✓

top of dam MAIN DIKE principal spillway _____

other ~~&~~ 72'± Above downstream toe - MAIN DIKE (@Center)

11. Summary of Deficiencies Noted:

Growth (Trees and Brush) on Embankment ✓

Animal Burrows and ~~washouts~~ ✓

Damage to slopes or top of dam —

Cracked or Damaged Masonry ✓

Evidence of Seepage ✓ heavy

Evidence of Piping ✓ 1 Piping boil observed 70'± beyond D.S. Toe of MAIN DIKE

Erosion —

Leaks ✓

Trash and/or debis impeding flow —

Clogged or blocked spillway Small Trees, Brush IN Spillway

Other _____

12. Remarks & Recommendations: (Fully Explain) ① Emergency Spillway
This dam has been poorly maintained & moderate to severe deterioration is in evidence. There are saplings growing in the spillway floor. There is a stepped spillway drop 450'± d.s. of the Conc. Entrance Weir which is located at the spillway entrance on the west end of the main Dike or Embankment. The spillway floor just upstream of this d.s. stepped spillway drop is paved with grouted Granite Slabs and 10'± upstream of the first stepped The granite floor has collapsed forming a hole in this floor 6' (parallel to flow) × 12' (transverse to flow) × 2' deep. Just downstream of this structure at the lower spillway East Sidewall Toe, water is emerging from a 12" × 12" hole (Flowing 1/3-1/2 full).

② Secondary dike on the East Side of the impoundment
There is a light growth of brush on the U.S. face " " " heavy " of trees & brush on the downstream face. 350'± North of the intersection of the main & secondary dikes there are several pools of standing water just beyond the downstream toe (seepage indicated)

(Cont. on Sheet 3A)

13. Overall Condition:

1. Safe _____
2. Minor repairs needed _____
3. Conditionally safe - major repairs needed ✓ _____
4. Unsafe & possibly ✓ _____
5. Reservoir impoundment no longer exists (explain)

Recommend removal from inspection list _____

Fitchburg - Lovell Reservoir Dam No. 3-14-97

(Sheet 3A)

12. (Continued)

3. MAIN Dike or Embankment - South Side of Impound:

There is a heavy growth of brush on the downstream Slope. There is heavy Seepage Through This Embankment IN Spite of the existance of a Concrete Core wall. Some Fracturing of this wall is a possibility. The distance between the downstream Toe of this dam and the lower Pool (FALULAH Reservoir) is 150'± and a Gravel ~~blanket~~ BLANKet (150' x 200' width) has been placed here because of Severity of the Toe Seepage. There are NUMEROUS locations adjacent to this GRAV. pad where water is Flowing Through pools of water and deep (?2') deltas of Silt. ONE piping Boil WASNoted ON The East Side of this GRAV. Pad 70'± beyond The T of Slope. 2 ~~=~~' 12" CI pipes have been placed at the South Corners of The GRAV Pad To Carry The Seepage Into The lower Reservoir. Some of The Seepage Probably enters The lower Pool

(Cont. on Sheet 3B)

Fitchburg - Lovell Reservoir - DAM No. 3-14-97-34
by way of Flow Through The Aquiferous
Gravel Pad. ½± way up the d.s. Slope
several Saturated patches were Noted.
Burrowing Animals (i.e. Woodchucks) were
observed on The d.s. Slope.

General:

Inspection of This dam and
Preliminary reconnaissance of other dams
in The Fitchburg water System indicates
That The system has been inadequately
maintained. Several of These dams (all
earth emb. Types) are experencing Heavy
leakage and The Structural Safety
of at least 2 of These dams
(Scott Reservoir. No-97-37 and Lovell Reservoir
This dam) is Questionable. Because of
The above and The Consequent Threat To
downstream life and property, The City
would be well advised To expeditoosly retain
a Consultant to give an indepth
INSPECTION To ALL of The Dams IN The
MUNICIPAL water System, USING INSTRUMENTATION
(ie Piezometersetc.) where warranted. The City
Could be Further Advised That more Specific Comments
Re These dams are Forth Coming (After Submission of my Entire Report PACKAGE

DESCRIPTION OF DAM

DISTRICT 3

Submitted by W. Regan Dam No. 3-14-97-34

Date 5/7/75 City/~~Town~~ Fitchburg

Name of Dam Lovell Reservoir

1. Location: Topo Sheet No. 19D

Provide 8½" x 11" in clear copy of topo map with location of Dam clearly indicated.

2. Year built: 1929 Year/s of subsequent repairs 1940,

3. Purpose of Dam: Water Supply ✓ Recreational

Irrigation Other

4. Drainage Area: 3.3 sq. mi. acres

5. Normal Ponding Area: 37± acres; ~~avg.~~ MAX depth 75'± (As Per City Records)

Impoundment: 400 Million gals.; -- acre ft.

6. No. and type of dwellings located adjacent to pond or reservoir

None i.e. summer homes, etc.

7. Dimensions of Dam: Length MAIN DAM 750'± Secondary Dike 1400'± Max. Height 80'±

Slopes: Upstream Face 2:1

Downstream Face 2:1 (Stepped

Width across top 10'±

8. Classification of Dam by Material:

Earth ✓ Conc. Masonry Core Stone Masonry (Conc CAPPED) Spillway

Timber Rockfill Other

9. A. Description of present land usage downstream of dam:

50 % ~~rural~~ Residential; 50 % urban. (describes 5 miles d.s. North Nashua River)

B. Is there a storage area or flood plain downstream of dam which could accomodate the impoundment in the event of a complete dam failure? yes no ✓.

DAM NO. 3-14-97-34

10. Risk to life and property in event of complete failure.

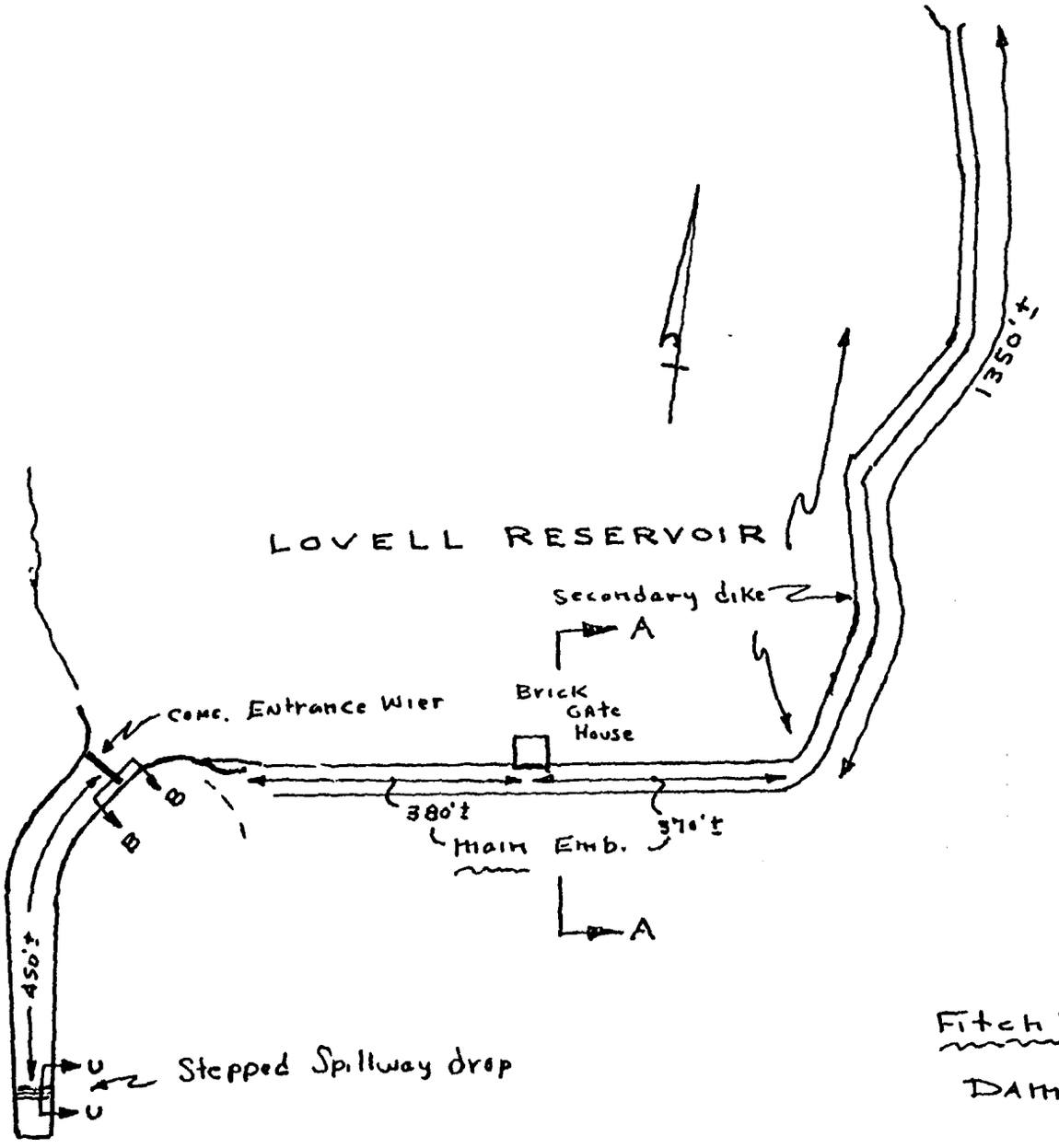
:e Note below

- No. of people _____.
- No. of homes _____.
- No. of Businesses _____.
- No. of industries _____. Type _____
- No. of utilities _____. Type _____
- Railroads _____.
- Other dams _____.
- Other _____.

11. Attach Sketch of dam to this form showing section and plan on 8½" x 11" sheet.

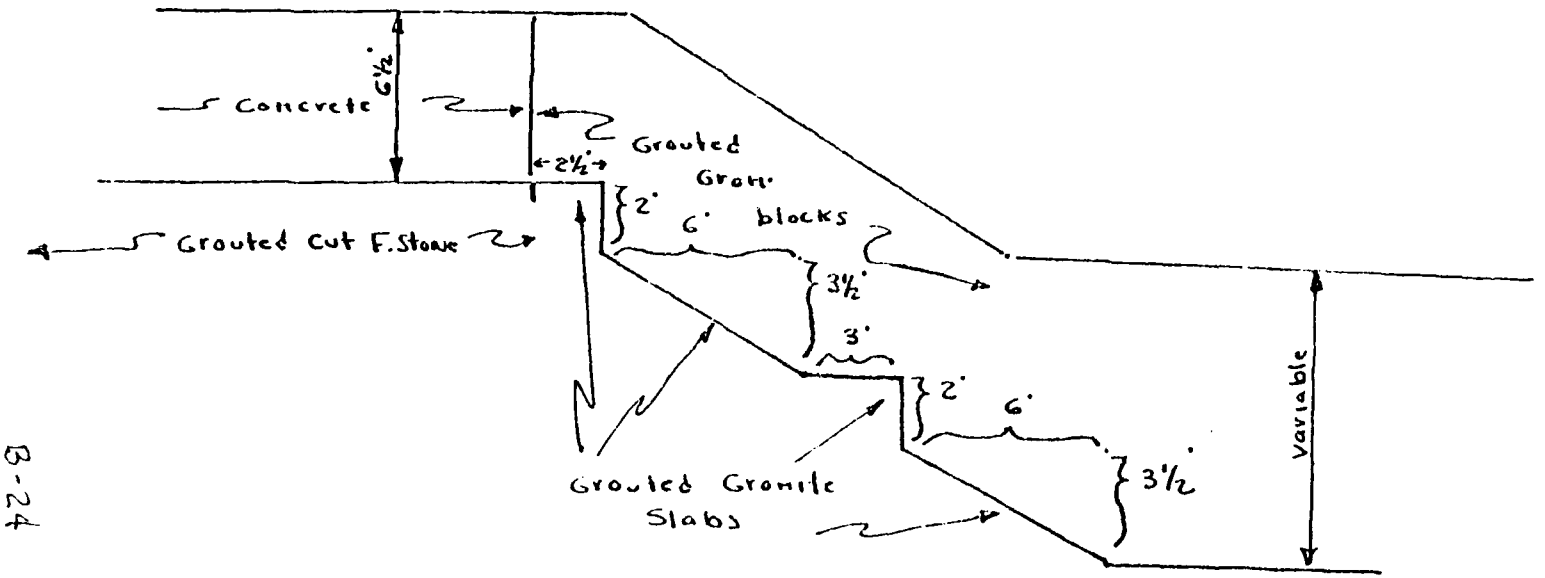
12. How to Locate: Access To This dam is Controlled by The city of Fitchburg Water dept. Contact Andy Provencial Fitch. Water dept. Supt. @ Kimball Place (off Rte 31) and he will have a man take you to the dam.

lote (10): The distance between this dam and The N. Nashua River is 6± miles. There is Some storage Along this but it appears To be inadequate. The discharge makes 9± Road Crossings, 1 Railroad crossing, & 1 X. Country Power line x.ing. The last 3rd of this distan is Through a well developed Area and due To Poor Storage & large impoundment The failure discharge would Constitute a definite Threat To life and Severe property damage is a Certainty



Fitchburg

DAM No. 3-14-97-34

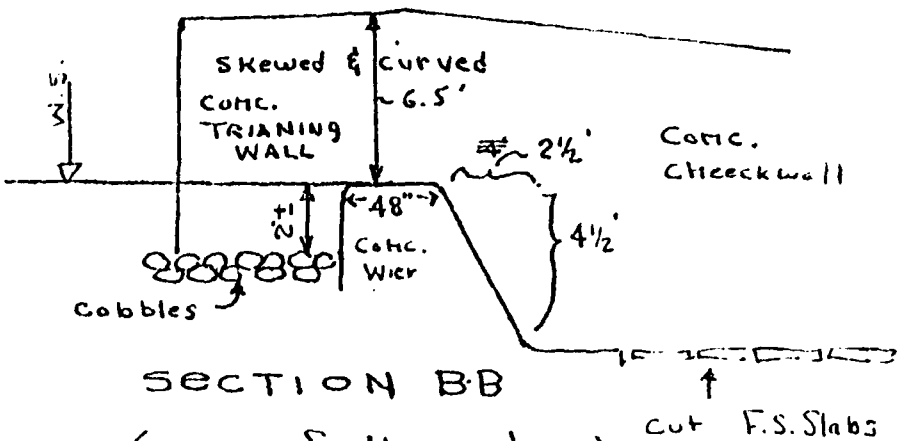


B-24

SECTION

C-C

(Lower Spillway drop)



SECTION BB

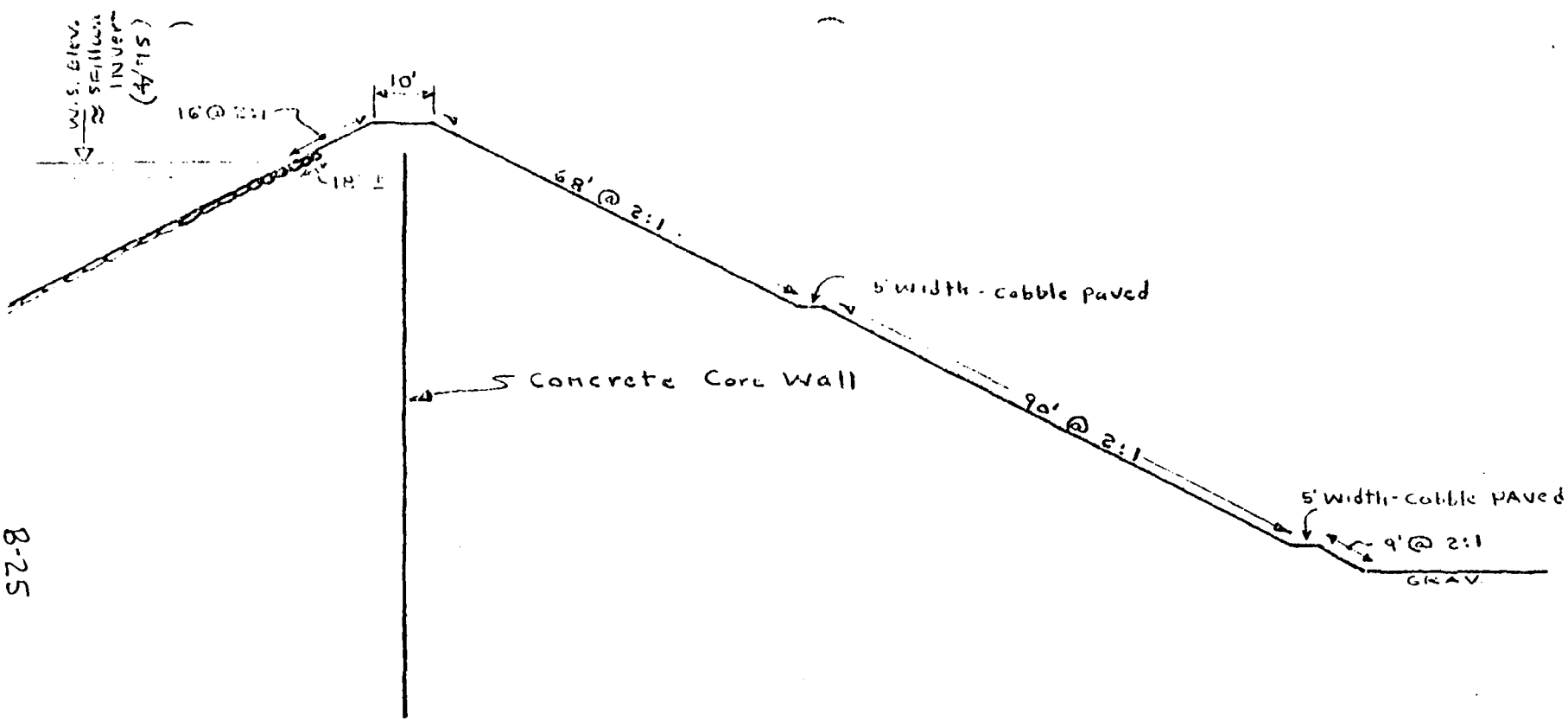
(upper Spillway drop)

(Wier X.Sect.)

FITCHBURG

Lovell Reservoir

DAM No. 3-14-97-34



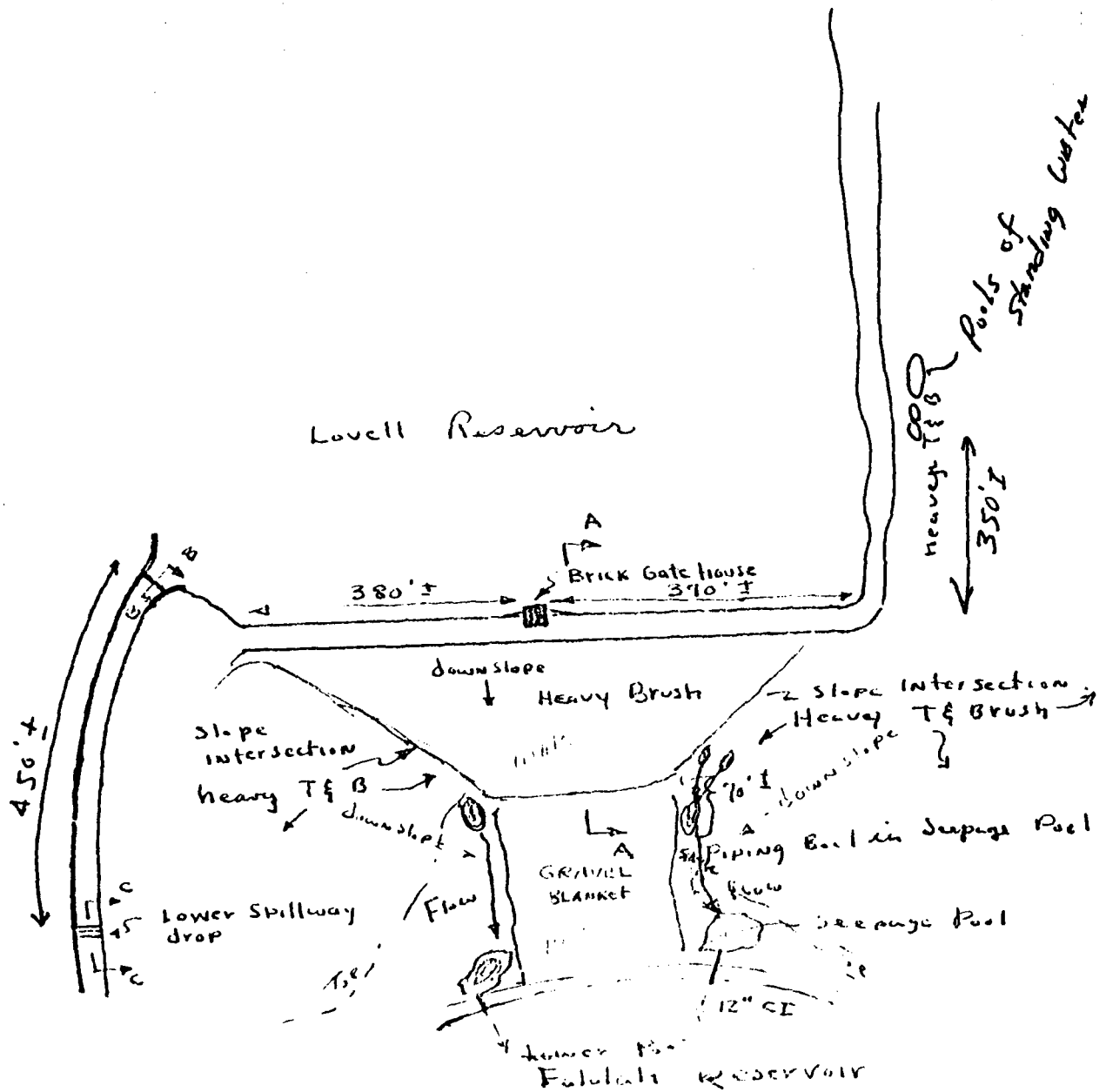
SZ-8

SECTION

A-A

FITCHBURG

Lovell Reservoir


Lovell Reservoir
Pools of standing water
Heavy T & B
350'±
A
Brick Gate house
380'±
390'±
B
C
450'±
Downslope
Heavy Brush
2 Slope Intersection
Heavy T & Brush
Slope Intersection
Heavy T & B
downslope
70'±
Downslope
A
GRAVEL BLANKET
Piping Boil in Seepage Pool
Flow
Seepage Pool
C
Lower Spillway drop
Flow
12" CI
Lower Pool
Fatulah Reservoir

TOWN Fitchburg DAM NO. 16-37

LOCATION _____ STREAM _____

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

D A M I N S P E C T I O N R E P O R T

Owned by City of Fitchburg Place Overall Reservoir Use _____

Inspected by T.C.M. & M.B.P. Date 3-11-69

Type of Dam _____ Condition _____

Water Dept. to lower water approx. 20 ft.

SPILLWAY

Flashboards in Place _____ Recent Repairs _____

Condition _____

Repairs Needed _____

EMBANKMENT

Recent Repairs _____

Condition _____

Repairs Needed _____

GATES

Recent Repairs _____

Condition _____

Repairs Needed _____

LEAKS

How Serious _____

DATE: _____ County Engineer

TOWN Fitchburg DAM NO. 15-34

LOCATION 800' westerly of Ridge Rd STREAM Fallulah Brook

"Lovell" Reservoir

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by City of Fitchburg Place Water Dept. Use Water supply

Inspected by [illegible] Date Sept 19-R

Type of Dam Earth and concrete Condition Good

SPILLWAY

Flashboards in Place _____ Recent Repairs _____

Condition The Eastern Gunite is in need of repairs to the

Repairs Needed joints, etc. on this spillway.

EMBANKMENT

Recent Repairs _____

Condition _____

Repairs Needed _____

GATES

Recent Repairs _____

Condition _____

Repairs Needed _____

LEAKS

How Serious _____

DATE: _____ County Engineer

TOWN Fitchburg DAM NO. 16-24

LOCATION Easterly - Rindge St. STREAM Falulah Brook

"Lower Reservoir"

WORCESTER COUNTY ENGINEERING DEPARTMENT
WORCESTER, MASSACHUSETTS

D A M I N S P E C T I O N R E P O R T

Owned by City of Fitchburg Place Upper Dam Use Storage

Inspected by W.L. Date Oct. 19, 1964

Type of Dam Earth and concrete Condition Fair

SPILLWAY

Flashboards in Place None Recent Repairs None

Condition Good condition

Repairs Needed Trees and brush on the concrete wall

EMBANKMENT

Recent Repairs None

Condition There is some small brush on the embankment

Repairs Needed None

GATES

Recent Repairs None

Condition Good condition

Repairs Needed The gates are open

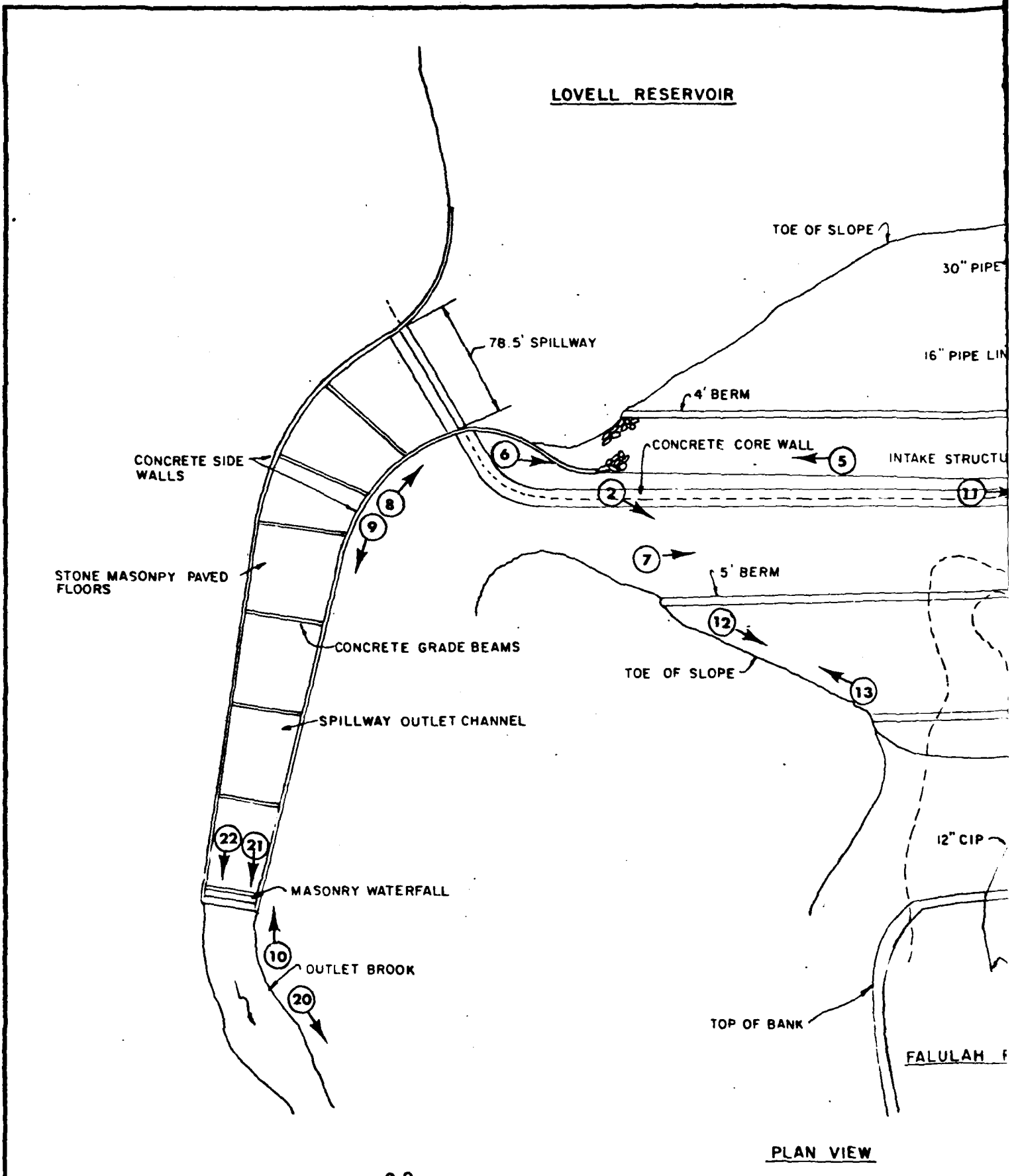
LEAKS

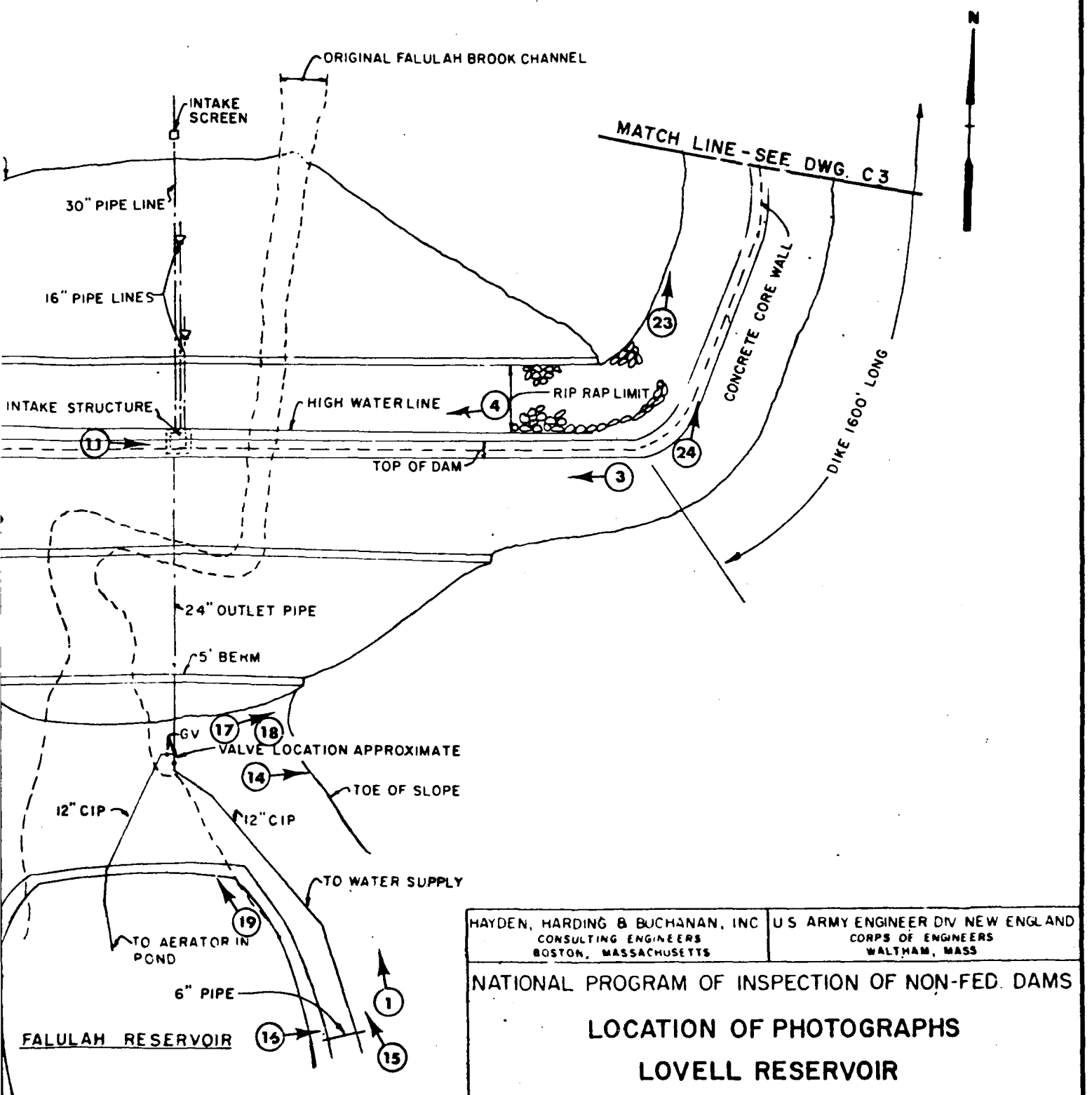
How Serious No leaks

DATE: County Engineer

APPENDIX C

PHOTOGRAPHS


LOVELL RESERVOIR
TOE OF SLOPE
30" PIPE
78.5' SPILLWAY
16" PIPE LIN
4' BERM
CONCRETE SIDE WALLS
CONCRETE CORE WALL
INTAKE STRUCTU
STONE MASONPY PAVED FLOORS
5' BERM
CONCRETE GRADE BEAMS
TOE OF SLOPE
SPILLWAY OUTLET CHANNEL
12" CIP
MASONRY WATERFALL
OUTLET BROOK
TOP OF BANK
FALULAH F
PLAN VIEW



HAYDEN, HARDING & BUCHANAN, INC CONSULTING ENGINEERS BOSTON, MASSACHUSETTS	U S ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS

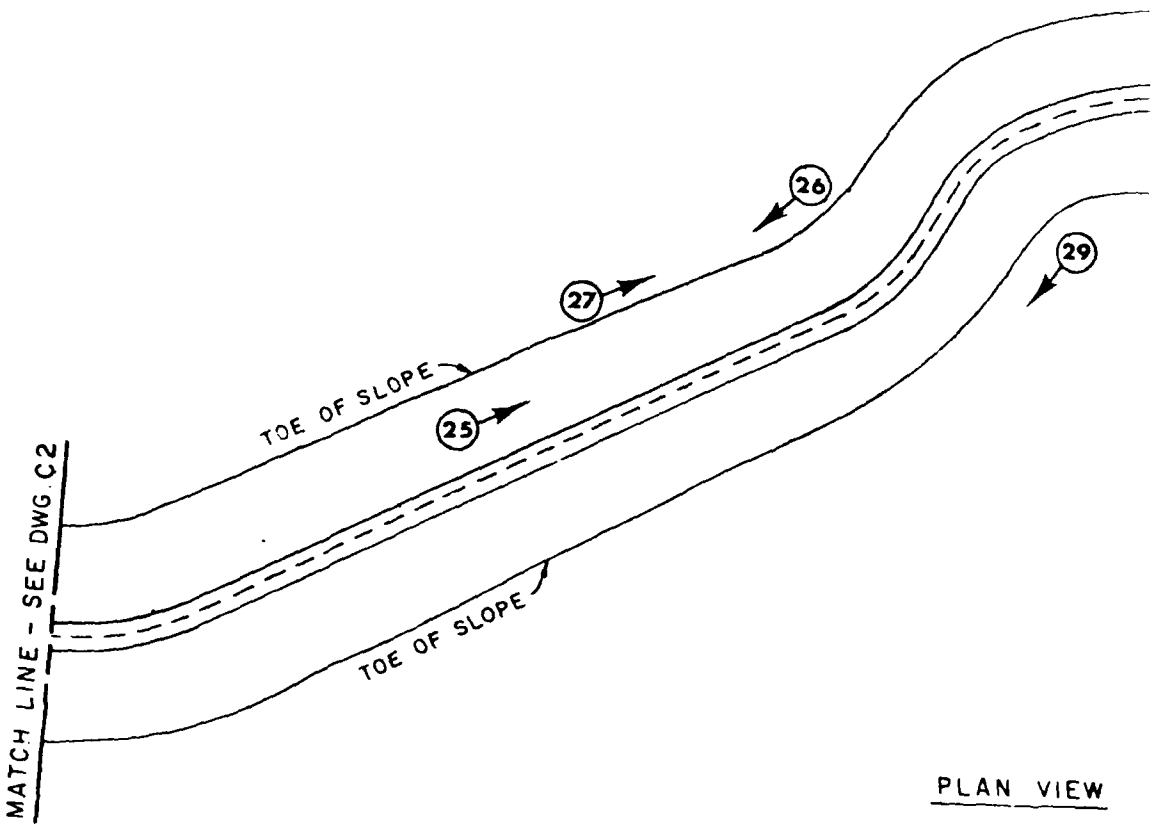
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION OF PHOTOGRAPHS
LOVELL RESERVOIR

FITCHBURG MASSACHUSETTS

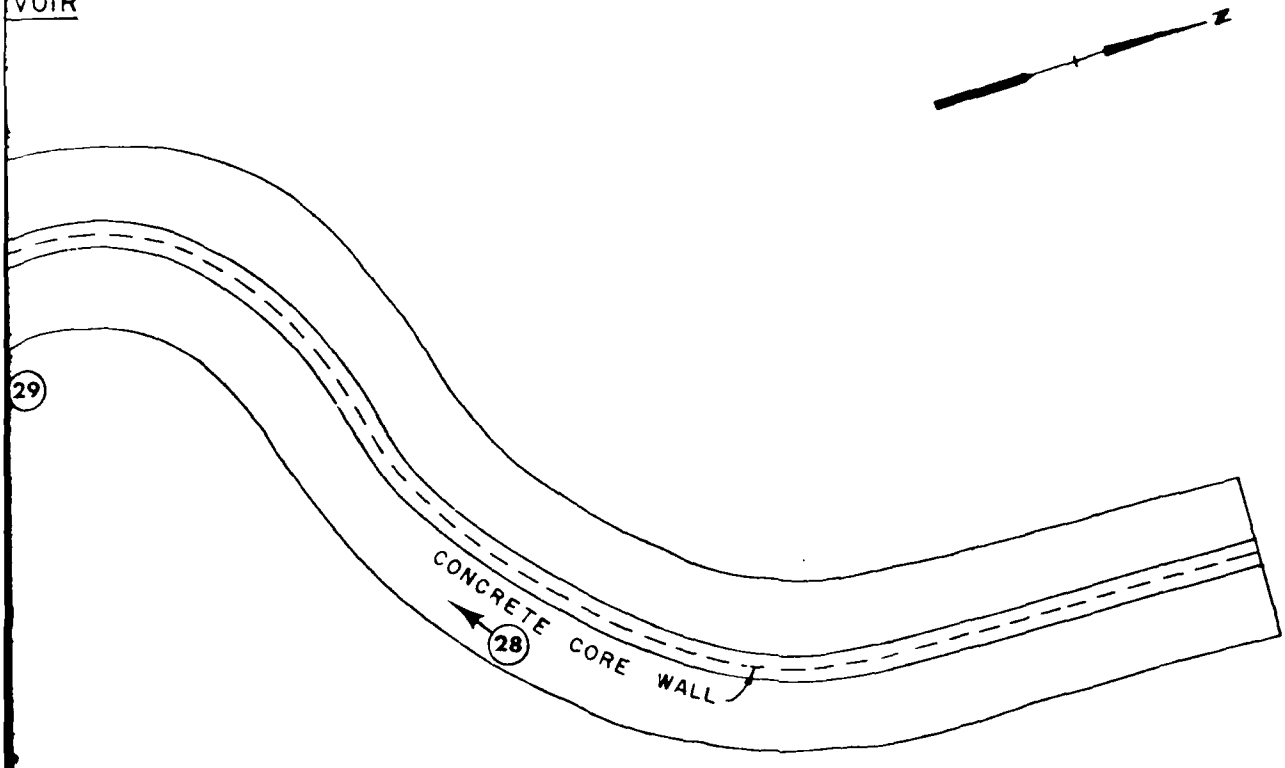
			SCALE NOT TO SCALE
			DATE JULY 1980

LOVELL RESERVOIR



PLAN VIEW

VOIR



IEW

HAYDEN, HARDING & BUCHANAN, INC. CONSULTING ENGINEERS BOSTON, MASSACHUSETTS	U.S. ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION OF PHOTOGRAPHS
LOVELL RESERVOIR

FITCHBURG MASSACHUSETTS

SCALE NOT TO SCALE

DATE JULY, 1980

PLAN DEVELOPED FROM RECORD DRAWINGS AND ON-SITE INSPECTION.

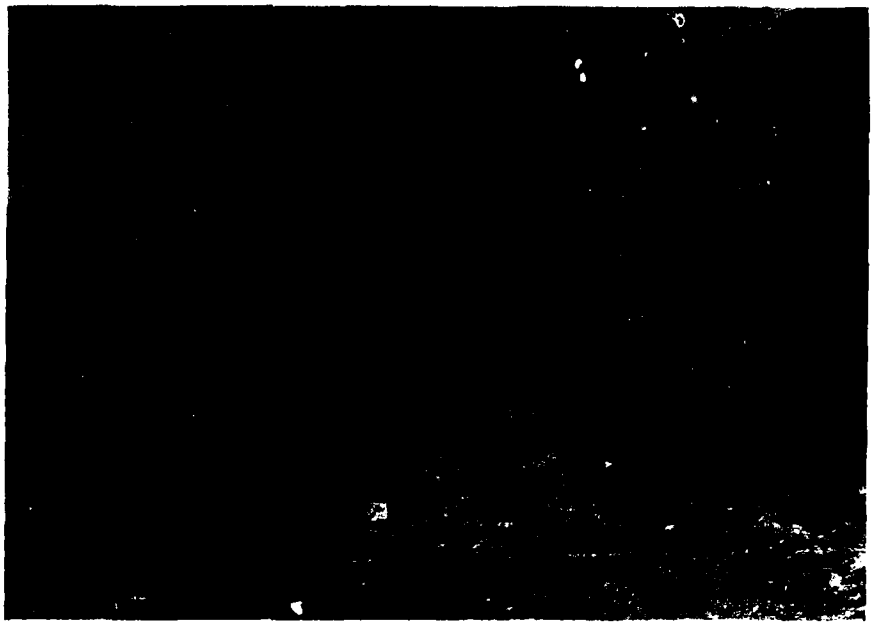
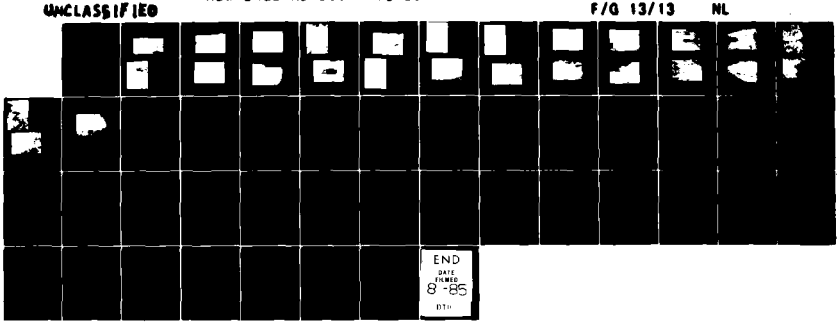


PHOTO NO. 1 View of downstream face with Falulah Reservoir in left foreground.

PHOTO NO. 2 Downstream view showing Falulah Reservoir.

AD-A155 816 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
LOVELL RESERVOIR DAM (..(U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV AUG 80

UNCLASSIFIED F/G 13/13 NL



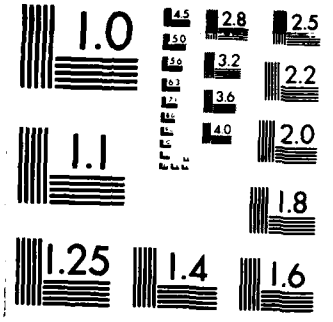


PHOTO NO. 3 View of crest from the left abutment.

PHOTO NO. 4 View of upstream face from the left abutment; note reservoir level near the top of riprap.

PHOTO NO. 5 Spillway entrance on right abutment as viewed from the center of the crest. Note curved training walls.

PHOTO NO. 6 View of upstream face and left bank dike (in background) from the left side of the spillway weir.

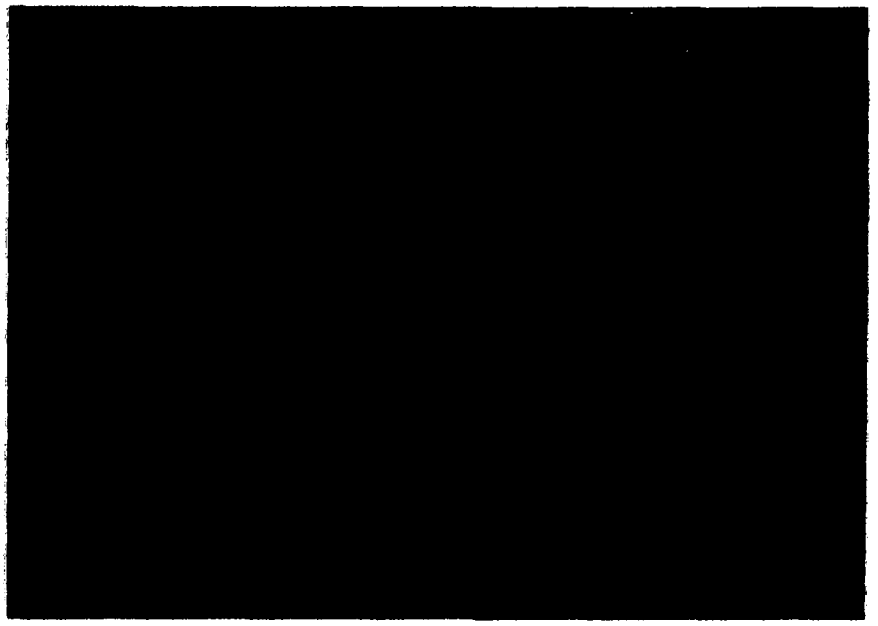


PHOTO NO. 7 Downstream face as viewed from the right abutment. Note surface drainage bench near mid-height.

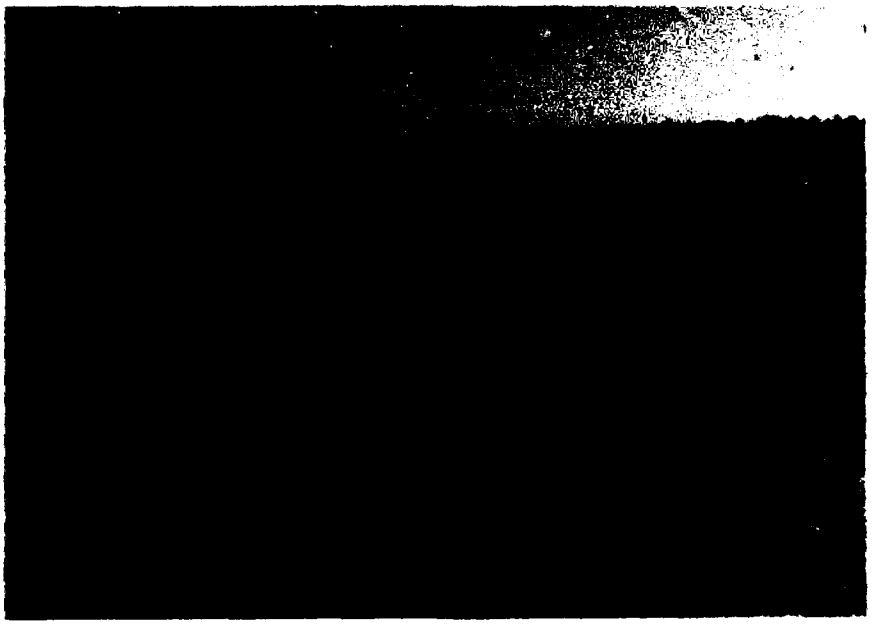


PHOTO NO. 8 View of spillway weir looking upstream. Note dike along upstream shoreline.

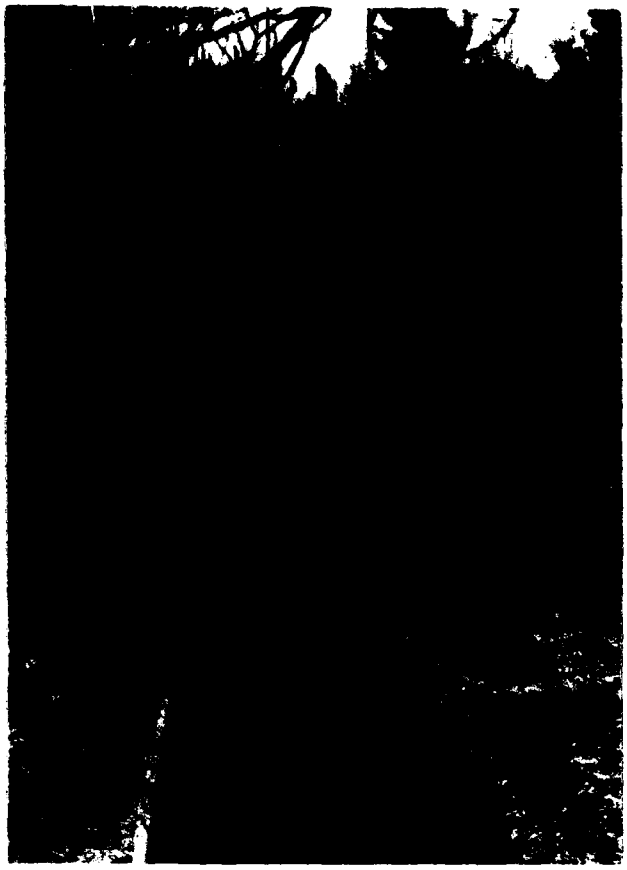


PHOTO NO. 9 View of downstream spillway channel showing brush growth.

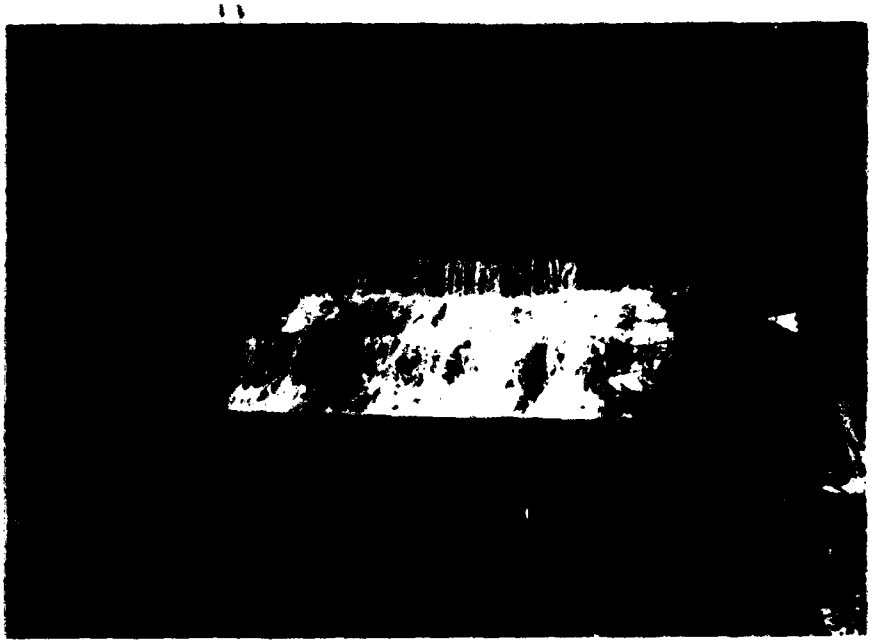


PHOTO NO. 10 View of masonry waterfall at end of outlet channel.

PHOTO NO. 11 Sluice gate handles for intake pipes at intake structure.

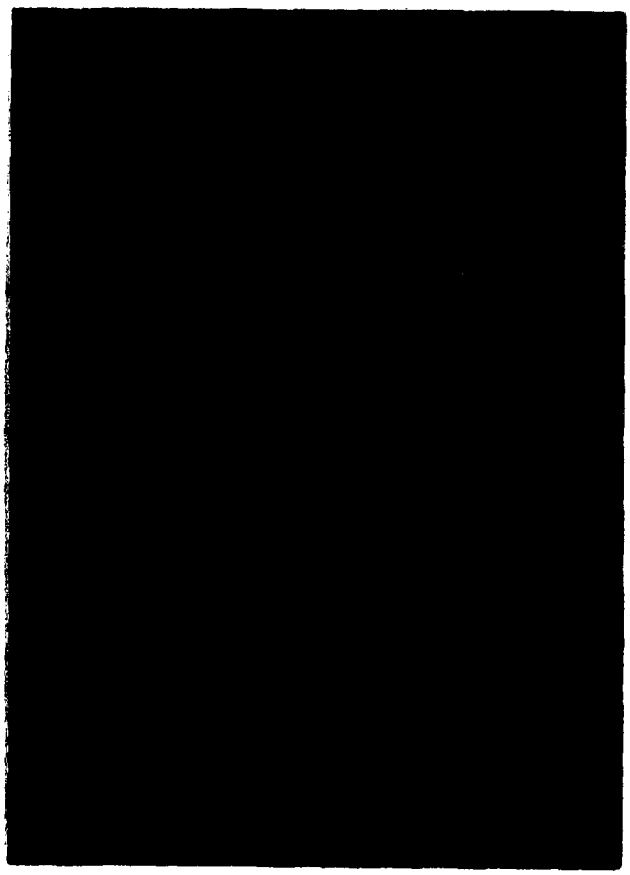


PHOTO NO. 12 View of drainage paths produced by seepage at the right abutment contact as seen from drainage bench on downstream face.

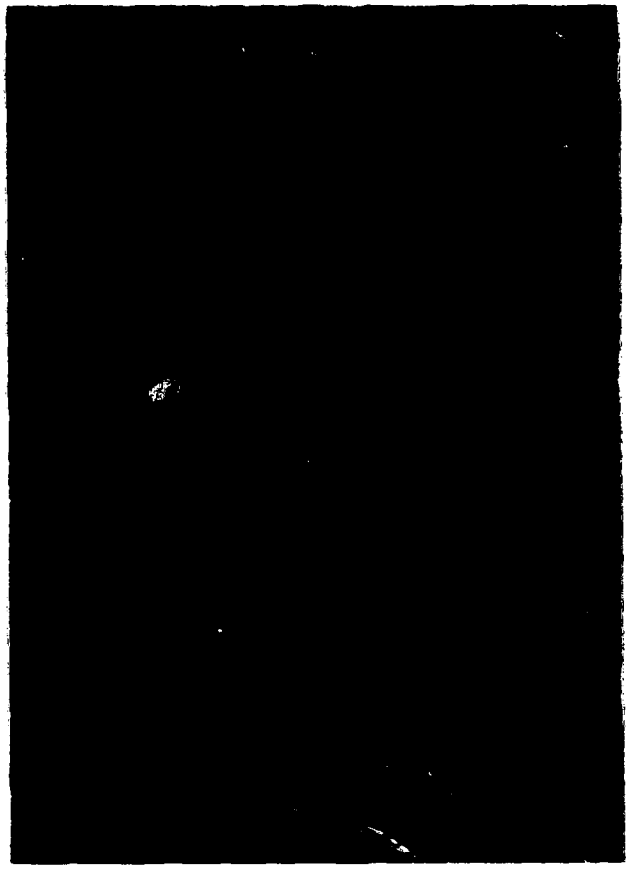


PHOTO NO. 13 Close-up of seepage paths in Photo 12, viewed from downstream.

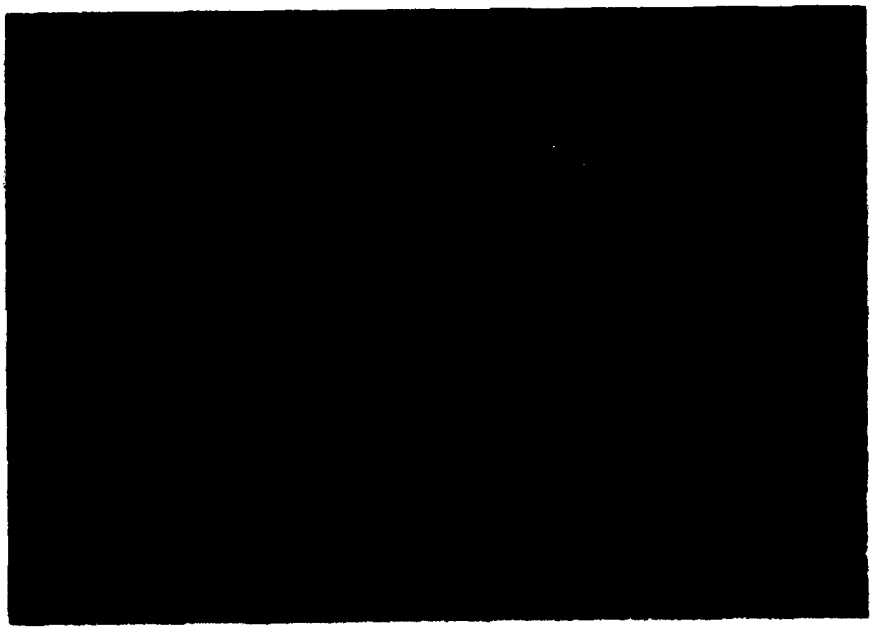


PHOTO NO. 14 General view of the left abutment and wet area, with recently placed gravel pad in foreground.

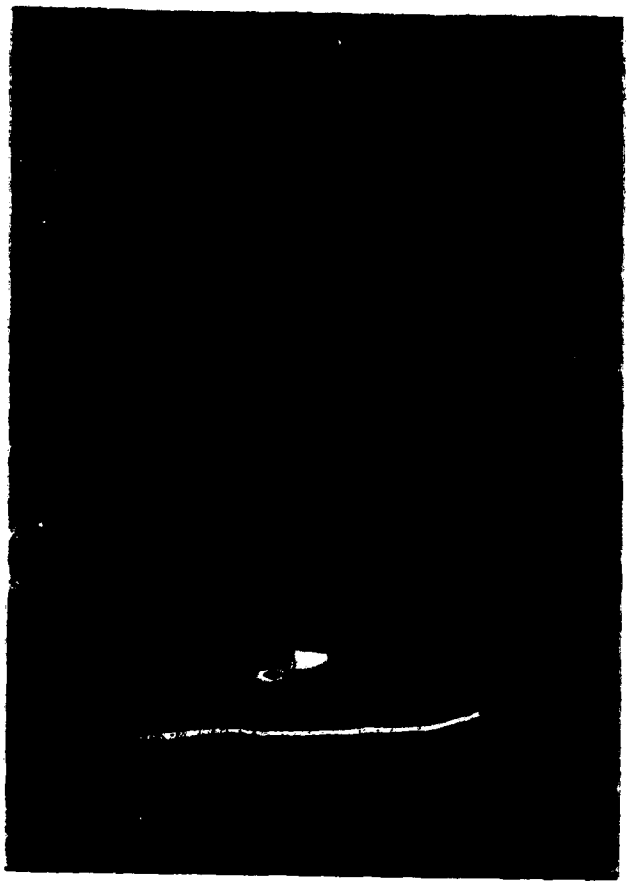


PHOTO NO. 15 View of wet area and inlet of pipe in Photo No. 16.

PHOTO NO. 16 Discharge of pipe draining wet area at the toe of the dam near the left abutment; water discharges into Falulah Reservoir.

PHOTO NO. 17 View of downstream face and left abutment. Person standing on face marks the approximate elevation of the surface of seepage exiting from the dam.

PHOTO NO. 18 Close-up view of seepage through downstream face approximately 15 ft. above the toe; note silty appearance caused by uncovering the seep. Similar seeps were discovered at approximately the same elevation along much of the downstream face.

PHOTO NO. 19 Discharge of pipe into Falulah Reservoir; possibly part of a downstream drainage system for the dam.

PHOTO NO. 20 Outlet channel below waterfall.

Photo No. 21 Voids in left side of spillway channel upstream of masonry waterfall.

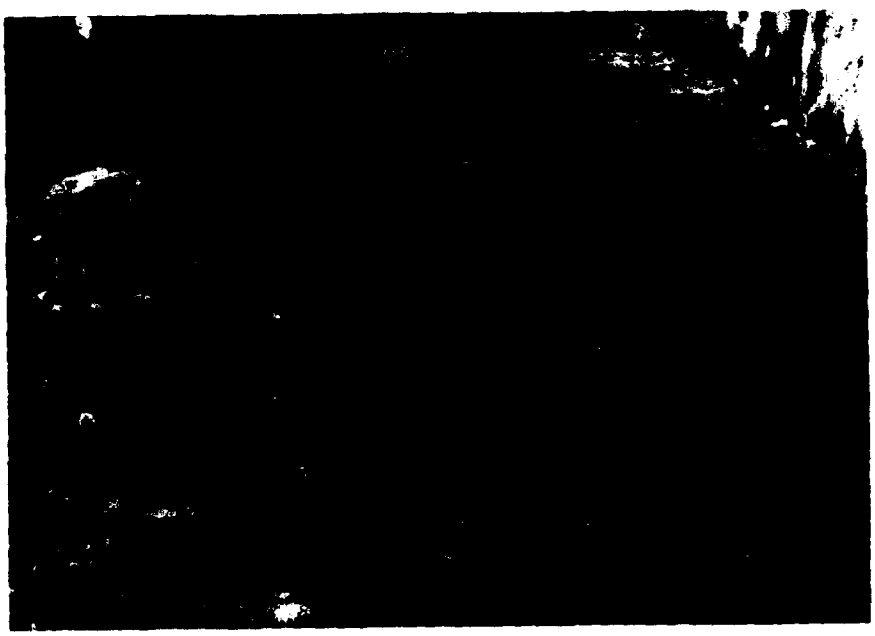


Photo No. 22 Voids in right side of spillway channel upstream of masonry waterfall.

Photo No. 23 Upstream slope of dike viewed from right abutment which is in contact with main dam.

Photo No. 24 Crest of dike viewed from dam/dike intersection.

Photo No. 25 Regrowth on maple tree stump located on upstream slope.

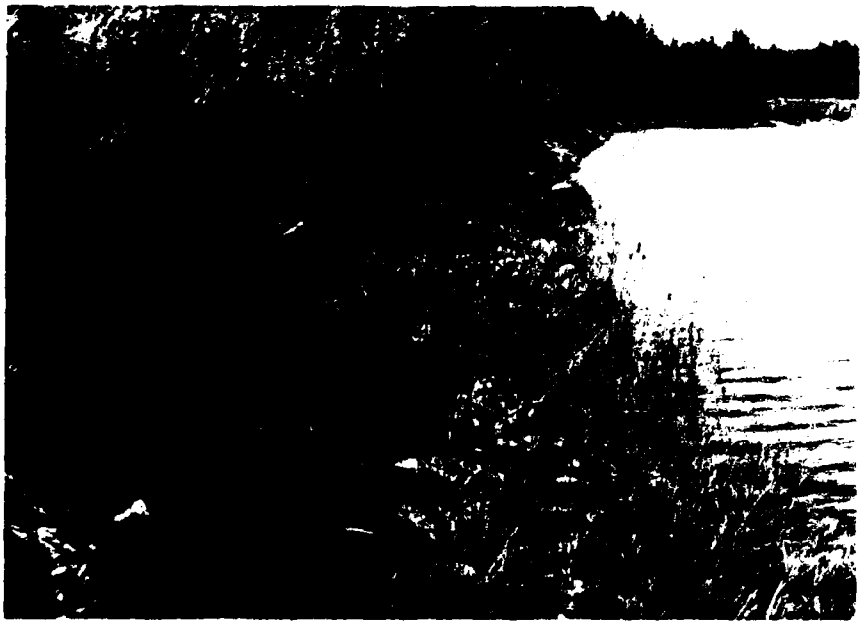


Photo No. 26 Slump in riprap.

Photo No. 27 Area of small size riprap which is supporting vegetation.

Photo No. 28 Downstream slope at a point 550 ft. right of left abutment.

Photo No. 29 Downstream slope at a point 850 ft. right of left abutment.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

JOB NO. 78.244.1
DATE 9-5-79
BY MA
CH'D BY FDD 9/24/79

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

SHEET NO. F-1
JOB Dams
SUBJECT Lowell
CLIENT Corps

LOVELL RESERVOIR

Built: 1927 to 1929
Water Supply: 1.9 mgd
Surface Area: 39.a.
Drainage Area: 3.24± s.m., 2070 a.
Feed by small brooks, ground flow and over-land flow.

Dam Height: 80' (hydraulic) } Size Class:
Dam Storage: 1173 a-f } Intermediate

Hazard Potential: High

Test Flood: PMF (rolling hills)

PMF Inflow = 2,000. cfs/sm × 3.24 = 6,480. cfs
spillway can pass 4320 cfs or 73% of 5,922. cfs outflow, dam is over-topped by 0.3± ft. to elev. 770.8±

Dam Failure Analysis

$$Q_b = {}^{8}/_{27} \times (0.4 \times 450) \times \sqrt{32.2} \times (80)^{1.5}$$

Q_b = 216,532. cfs failure outflow

Damage Due to Failure Outflow

Sta.	Item	Flood Stage
10+00	Fskuldh Res	18'.
18+00 to 30+00	Homes (10).	23' to 24'.
30+00 to 40+00	Homes (7).	24' to 17'.
40+00 to 60+00	Homes (0).	17' to 15'±
60+00 to 80+00	Homes (13).	15'±.

plus roads, utilities & misc. development.

PMF Outflow

Q_{P_1} = 6480 cfs (inflow) El_1 = 770.9 $Stor_1$ = 286 a.f. or 1.65"

$Q_{P_2} = 6480 \times \left(1 - \frac{1.65}{19}\right) = 5914 \pm$ cfs

El_2 = 770.8 ± $Stor_2$ = 280 or 1.62"

$Stor_{ave}$ = 1.635" runoff

$Q_{P_3} = 6480 \left(1 - \frac{1.635}{19}\right) = 5,922 \pm$ cfs

El_3 = 770.8 ±

Spillway Capacity = 4750± cfs
Overtopping Flow = 1172 cfs

Tailwater

Spillway does not discharge below dam. Tailwater from over-topping is about 0.6 ft. deep or elevation 691 ± depend. on actual ground elevations, which vary in this area. Main dam area ≈ 800 ft.

$Q = \frac{800}{2400}(1172) \cong 396$ cfs

D	WP	A	$R^{2/3}$	F	V	Q
0.5	150	75	0.63	6.44	4	304
0.75	155	116	0.82	"	5.3	616

D ≈ 0.6' at base of dam.

JOB NO. 78.244.1
DATE 4-6-79
BY MA
CH'D BY FDD 4/24/79

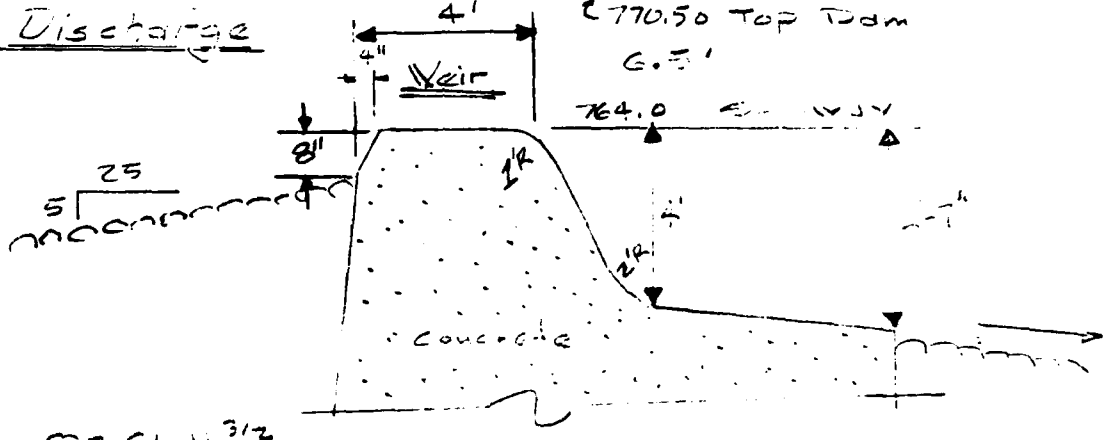
HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

SHEET NO.
JOB Dams
SUBJECT Cove II
CLIENT Corps

Storage

Elev	Area -a-	Ave A	D	a-f	Accum - Stor-
700	3.2	—	—	—	—
720	9.2	6.2	20	124	124
750	19.3	14.25	30	428	552
760	28.5	23.9	10	239	791
764	33.1	30.8	4	123	914
769	41.3	37.2	5	186	1100
770.5	56	48.65	1.5	73	1173

Discharge



$Q = CLH^{3/2}$

L/0	L	C	$H^{3/2}$	Q					
1	78.45	2.67	1	210	7'	78.45	3.32	18.52	4837
2	"	2.68	2.83	595	8'	"	"	22.62	5805
3	"	2.73	5.2	1114					
4	"	2.79	8	1751	El	Q			
5	"	3.07	11.18	2693	770.5	4400			
6	"	3.32	14.7	3828	770.7	5075			
6.5	"	3.32	16.6	4323	771	7075			

Over Overflow

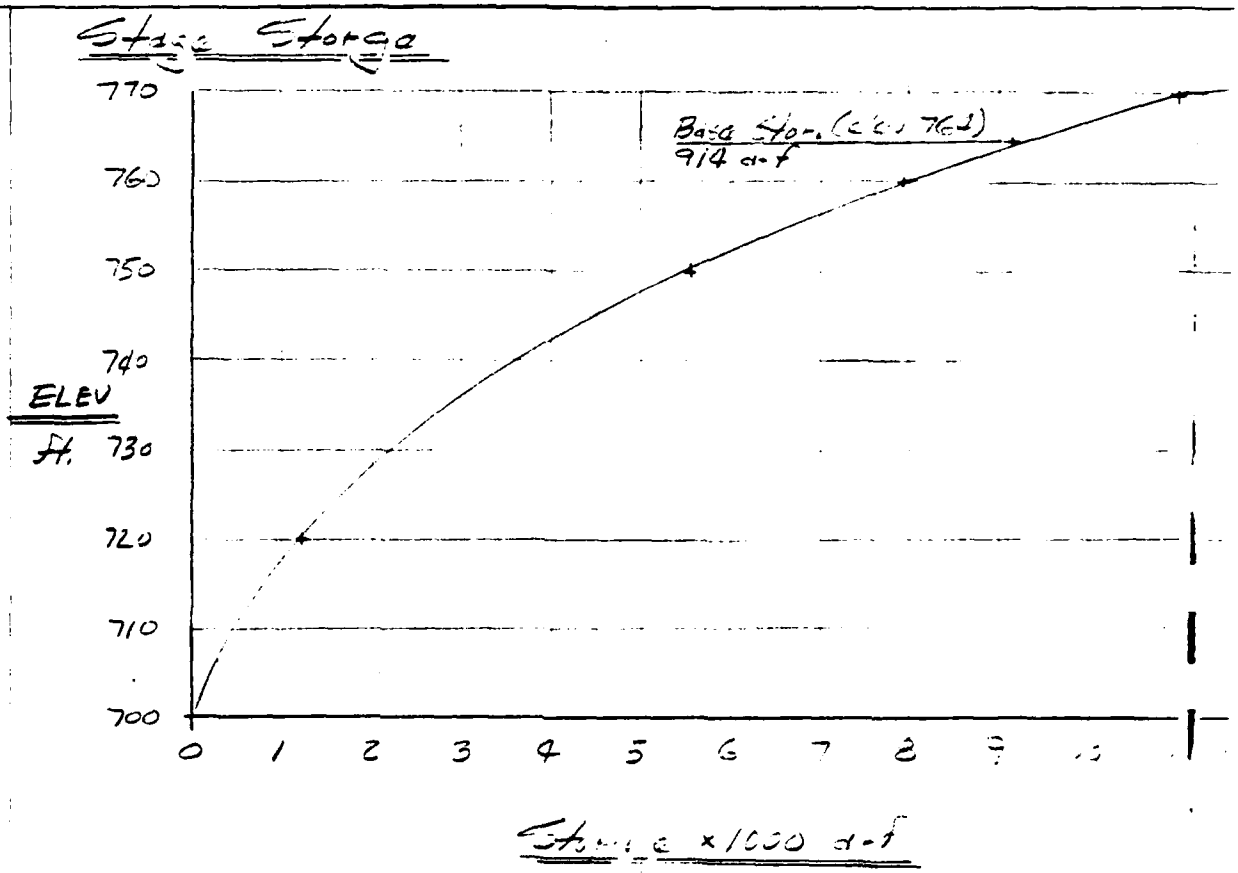
0.5	2400	2.68	.35	2251
0.2	"	2.68	0.09	577

$d \simeq 0.3' \pm$

JOB NO. 78.244.1
DATE 4-6-78
BY MA
CH'D BY FDD 4/24/78

HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

SHEET NO D4.1
JOB [illegible]
SUBJECT [illegible]
CLIENT [illegible]

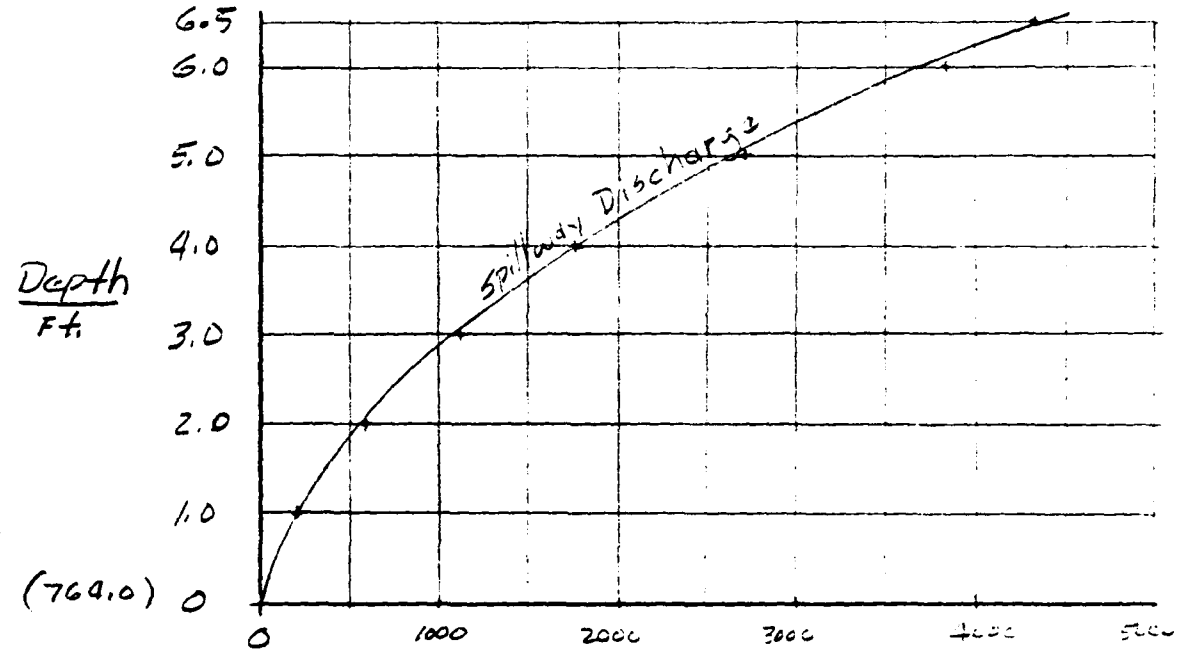


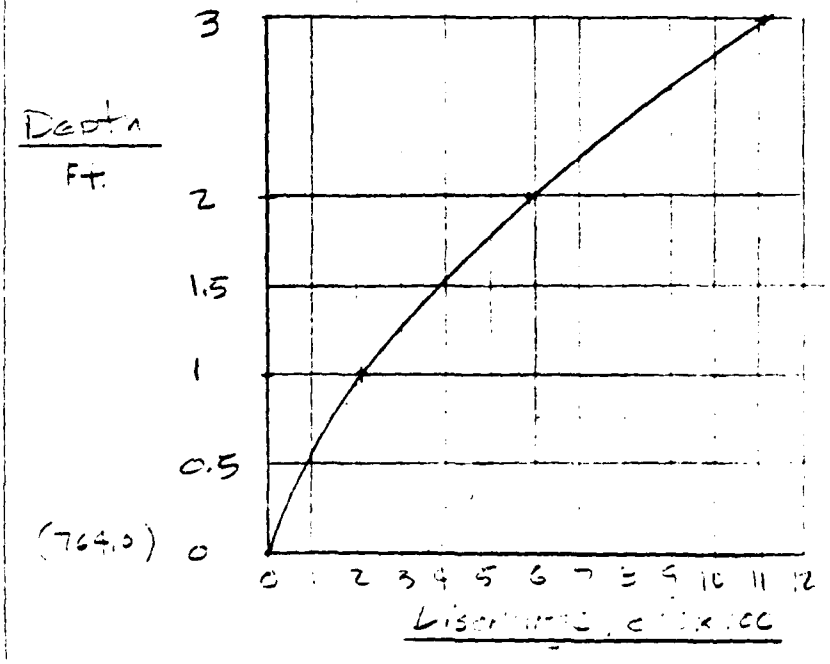
JOB NO. 73.294.1
DATE 5-6-79
BY MA
CH'D BY

HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

SHEET NO. D-4c
JOB [illegible]
SUBJECT [illegible]
CLIENT [illegible]

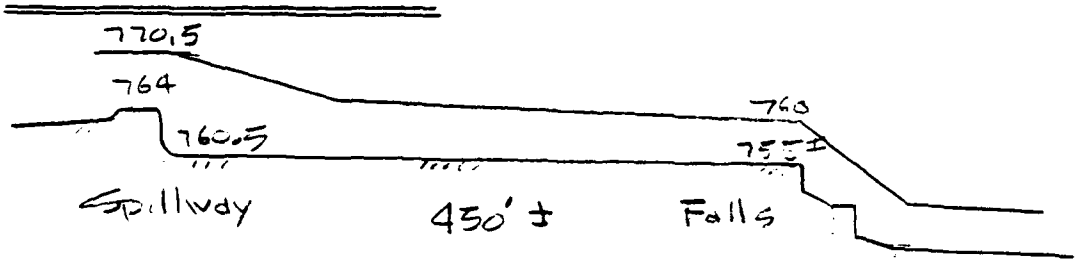
Spillway Discharge

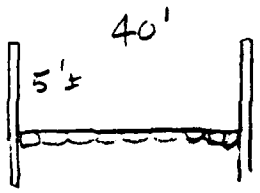




Enlargement of Lower Portion of Upper Curve

Outlet Channel





$S = \frac{5.5'}{450'} = 0.012'/'$

$V = \frac{1.486}{0.017} R^{2/3}(0.012)^{1/2} = R^{2/3}\,9.55$

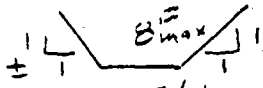
$Q = VA$

D	A	WP	$R^{2/3}$	F'	V	Q
5'	200'	50.	2.53	9.58	24±	4800±

$Q_{out} = 4750$ cfs $\approx Q_{channel} = 4800$ cfs
could overflow channel banks
depending on conditions, back water
may influence the spillway outflow

Brook Channel

$V = \frac{1.486}{0.06} R^{2/3}\left(\frac{5.0}{500}\right)^{1/2} = R^{2/3}\,5.94$



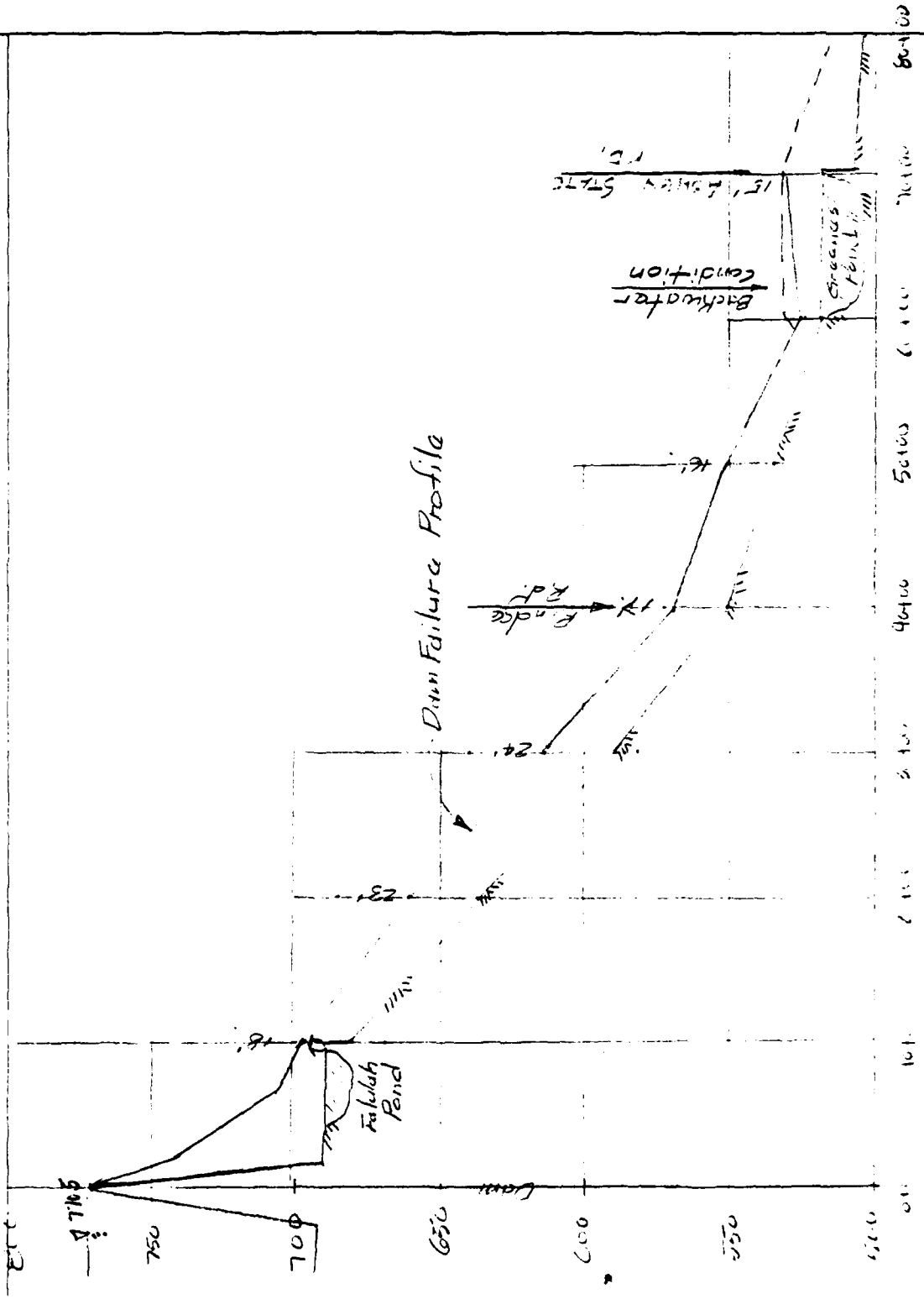
D	A	WP	$R^{2/3}$	F'	V	Q
8.	184.	38.	2.9	5.94	16.6	3100.±

not adequate for PMF outflow
will flow deeper above line
of excavated brook channel.

JOB NO. 7914.1
DATE 4-20-79
BY WIA
CH'D BY FBD 4/24/79

HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

SHEET NO 26
JOB Quinn
SUBJECT Cross
CLIENT Corps



JOB NO. 75.204.1
DATE 9-19-79
BY MA
CH'D BY FDD 9/24/79

HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

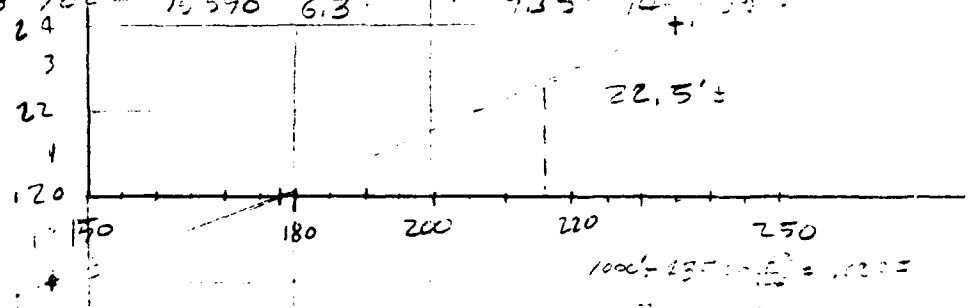
SHEET NO 27
JOB Adams
SUBJECT Levee
CLIENT Corps

Std 10+00

$n = 0.10$ $S^{1/2} = \left(\frac{690-680}{1000}\right)^{1/2} = 0.10$ $V = R^{2/3}(1.486)$

D	WP	A	$R^{2/3}$	F'	V	Q
f	f	f^2	-	-	f/s	cfs
20'	1000.	17550.	6.8	1.486	10.13	177,812.
25	1130.	22850.	7.5	"	11.14	254,563.
22	1060	21230.	7.5	"	11.06	235,000
13'	1000	15590	6.3	"	9.35	145,000

Q_{P_1} = 215,000 cfs



$Q_{P_1} = 216,500$ cfs $V_1 = \frac{14450 + 21750}{2}(.023) = 418$ cfs

$S = 1173$, $1/2(S) = 587$ cfs

$Q_{P_2} = 215,000\left(1 - \frac{416}{1173}\right) = 139,770$ cfs $d = 11.75$

$V_2 = \frac{14400 + 15340}{2}(.023) \cong 343$ cfs $V_a = 379$

$Q_{P_3} = 214,000\left(1 - \frac{379}{1173}\right) = 144,000 \pm$ cfs

$E_1 = 690$

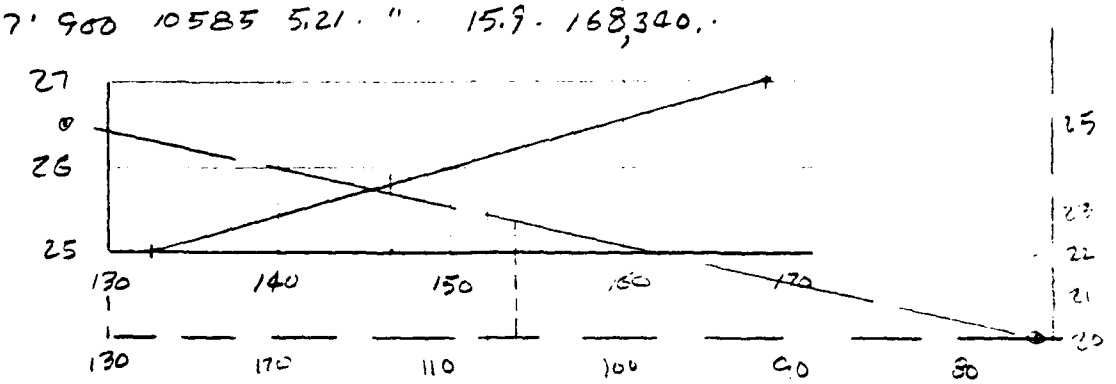
Consider a section ... d = 18.4± ... to the ... allow for this ...

Std 20+00

$n = 0.16 \quad S^{1/2} = \left(\frac{680 - 638}{1000}\right)^{1/2} = 0.205 \quad V = R^{2/3}(3.05)$

D	WP	A	$R^{2/3}$	F'	V	Q
20'	450	4985	5	3.05	15.3	76,163.
25'	830'	8885	4.9	"	14.9	132,670.
27'	900	10585	5.21	"	15.9	168,340.

$Q_{P_1} = 146,550$ cfs



$Q_{P_1} = 146,550 \quad d = 25.8' \quad A = 9565$

$V_1 = \frac{18545 + 9565}{2}(0.023) = 32\%$ cfs OK

$Q_{P_2} = 146,550\left(1 - \frac{32\%}{1173}\right) = 106,163 \quad d = 22.75'$

$V_2 = \frac{18545 + 7130}{2}(0.023) = \quad V_2 =$

$Q_{P_3} = 146,550\left(1 - \frac{309}{1173}\right) = 108,000 \pm$ cfs $d = 22.8'$

$F_1 = 66 \pm$

JOB NO. 78.294.1
DATE 4-20-79
BY MA
CH'D BY FDD 4/24/79

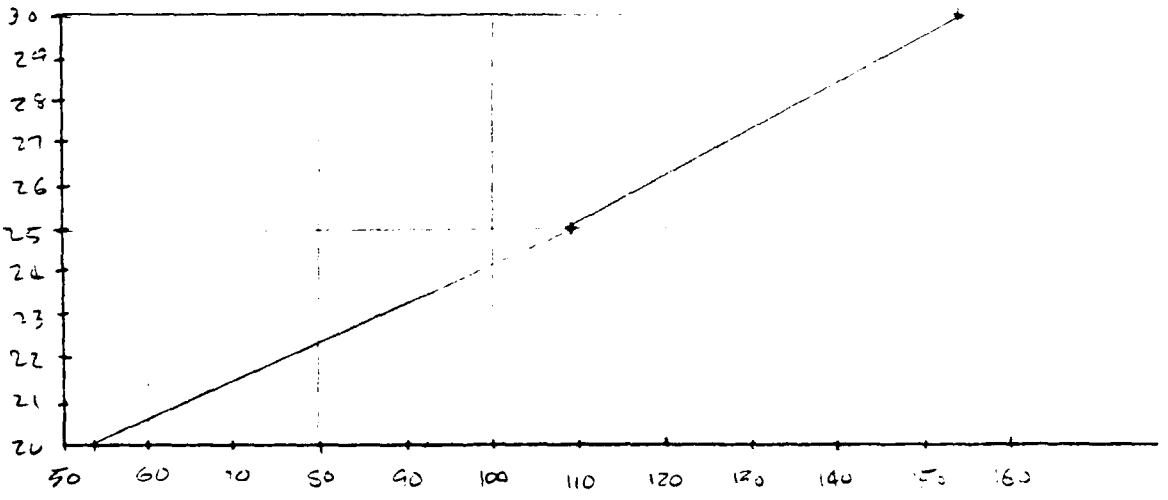
HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

SHEET NO D-
JOB Dams
SUBJECT Local
CLIENT Corps

Sta 30+00

$n = 0.10 \quad S^{1/2} = \left(\frac{635 - 590}{1000}\right)^{1/2} = 0.22 \quad V = R^{2/3}(3.25)$

L	WP	A	$R^{2/3}$	F'	V	Q
20	350	3500	4.7	3.25	15.2	53,200 ±
30	580	8100	5.9	"	19.	154,000 ±
25	480	6100	5.5	"	17.85	108,900 ±



$Q_{P_1} = 108000 \quad d = 25' \quad A = 6100$

$V_1 = \frac{8400 + 6100}{2}(.023) = 167 \text{ c.f.s}$

$Q_{P_2} = 108000\left(1 - \frac{167}{1173}\right) = 92,700 \pm, \quad d = 23.5'$

$V_2 = \frac{8400 + 5320}{2}(0.023) = 158 \quad V_a = 163 \pm \text{ c.f.s}$

$Q_{P_3} = 108000\left(1 - \frac{163}{1173}\right) = 93,050 \text{ c.f.s} \quad d = 23.5'$

El = 614 ±

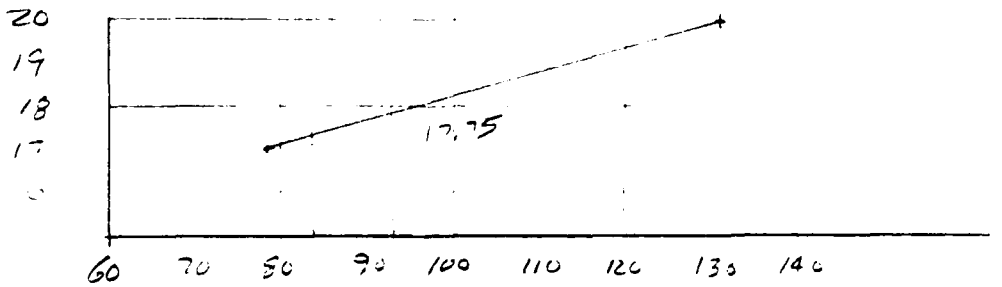
HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

Sta 40+00

$n = 0.10 \quad S^{1/2} = \left(\frac{590 - 555}{1000}\right)^{1/2} = 0.1871 \quad V = R^{2/3}(2.78)$

D	WP	A	$R^{2/3}$	F'	V	Q
25	1000	14375	6	2.78	16.6	238,370
20	900	9625	4.9	"	13.6	131,000±
15	815	5375	3.54	"	9.8	52880
17	865	6975	4.05	"	11.3	78516

$Q_{P_1} = 93000$



$Q_{P_1} = 93000 \quad V_1 = \frac{5710 + 7638}{2}(0.023) = 153.5$ c.f.s.

$Q_{P_2} = 93000\left(1 - \frac{153.5}{1173}\right) = 80{,}830$

$V_2 = \frac{5710 + 7250}{2}(.023) = 148 \quad V_a = 151$ c.f.s.

$Q_{P_3} = 93000\left(1 - \frac{151}{1173}\right) = 81{,}032$ c.f.s.

$d = 17.1\pm$

Elev = 572±

JOB NO. 78.244.1
DATE 9-20-79
BY WLL
CH'D BY EDD 4/24/79

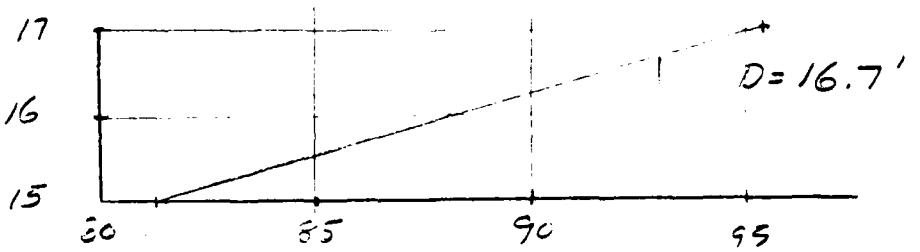
HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

SHEET NO. 8'
JOB Drums
SUBJECT Cedar
CLIENT Corps

Sta 40+00 A

$n = 0.10 \quad S^{1/2} = \left(\frac{590-565}{1000}\right)^{1/2} = 0.158$

D	WP	A	$R^{2/3}$	F'	V	Q
15	700	7250	4.79	2.34	11.2	81240 ±
17	900	8830	4.62	"	10.81	95420 ±



$Q_{P1} = 93{,}000$

Depth over Ridge Rd ± 16.7'

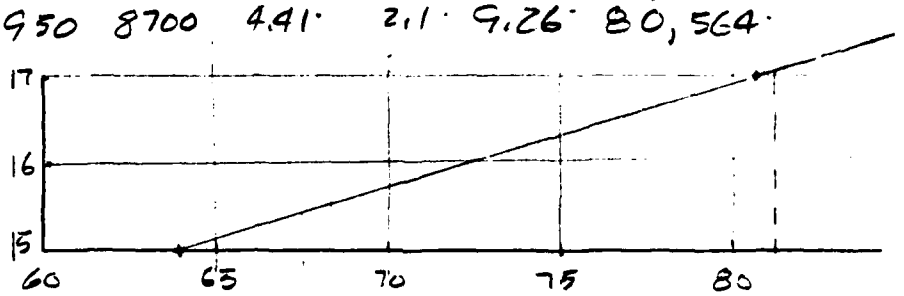
Elev 592 ±

Std 50+00

$n = 0.10 \quad S^{1/2} = \left(\frac{555-535}{1000}\right)^{1/2} = 0.1414 \quad V = R^{2/3}(2.1\cdot)$

D	WP	A	$R^{2/3}$	F'	V	Q
15	750	6900	4.42	2.1	9.3	64,100 ±
17	950	8700	4.41	2.1	9.26	80,564

$Q_{12} = 81{,}000 \pm$



$Q_{P_1} = 81{,}000 \cdot \quad V_1 = \frac{7400+8700}{2}(0.023) = 185.2 \cdot \text{c.f.}$

$Q_{P_2} = 81{,}000 \cdot \left(1 - \frac{185.2}{1173}\right) = 68{,}215 \cdot \quad d_2 = 15.4 \cdot$

$V_2 = \frac{7400+7260}{2}(.023) = 168.6 \cdot \quad V_a = 176.9 \cdot$

$Q_{P_3} = 81{,}000 \cdot \left(1 - \frac{176.9}{1173}\right) = 68{,}785 \cdot \quad d_3$

$d = 15.5 \pm$

El = 535 ±

JOB NO. 78.244.1
DATE 4-20-79
BY MA
CH'D BY FDA 4/24/79

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

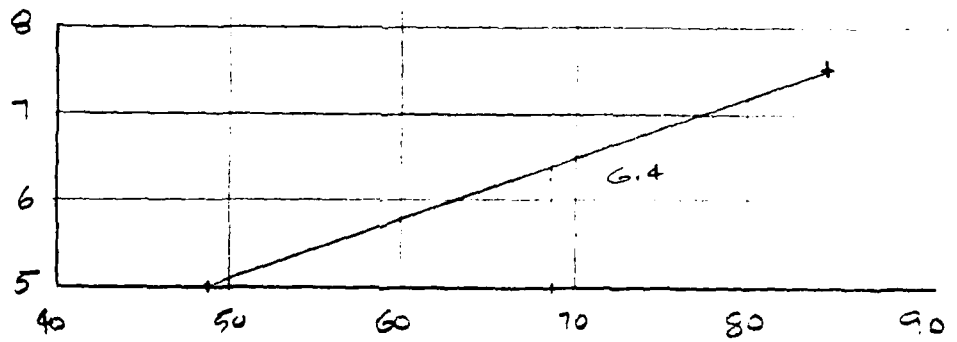
SHEET NO 21
JOB Dams
SUBJECT Lovell
CLIENT Corps

Sta 60+00

$n = 0.10$ $S^{1/2} = \left(\frac{535-518}{1000}\right)^{1/2} = 0.1304$ $V = R^{2/3}(1.94)$

D	WP	A	$R^{2/3}$	F'	V	Q
10	175	6000	10.7	1.94	20.7	124,300
5'	110	2850	8.85	1.94	17.2	48940.
7.5	145	4425	9.88	"	19.16	84,793.

$Q_{P_1} = 68,785.$



$Q_{P_1} = 68,785$ $V_1 = \frac{8000+3732}{2}(.023) = 135.$

$Q_{P_2} = 68,785\left(1 - \frac{135}{1173}\right) = 60,874;$ $d_2 = 5.9.$

$V_2 = \frac{8000+3417}{2}(.023) = 131.2$ $V_a = 133.1$

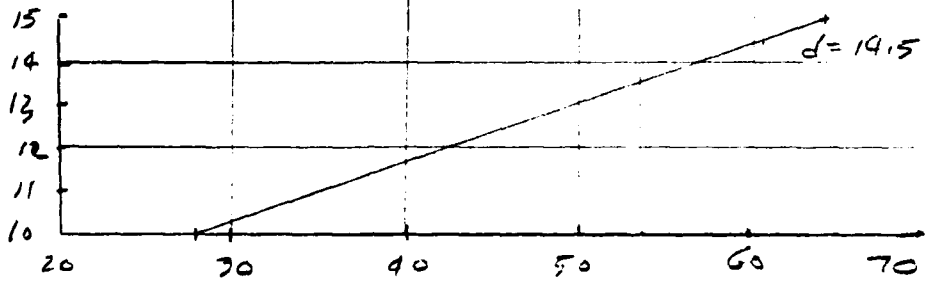
$Q_{P_3} = 68,785\left(1 - \frac{133.1}{1173}\right) = 61,000 \pm.$ $d = 6'.$

$EI = 524 \pm.$

Sta 70+00 $Q_{P_1} = 61000.$

$n = 0.10$ $S^{1/2} = \left(\frac{518-470}{1000}\right)^{1/2} = 0.0894$ $V = R^{.67}(1.33)$

D	WP	A	$R^{2/3}$	F'	V	Q
10	550	4850	4.3	1.33	5.72	27,733.
15	650	8600	5.64	"	7.5	64,538.



$Q_{P_1} = 61000.$ $V_1 = \frac{3550 + 8200}{2}(.023) = 135.1$

$Q_{P_2} = 61000\left(1 - \frac{135.1}{1173.}\right) = 53,973.$ $d_2 = 13.5$

$V_2 = \frac{3550 + 7445}{2}(.023) = 126.4$ $V_a = 130.8$

$Q_{P_3} = 61000\left(1 - \frac{130.8}{1173.}\right) = 54,202. \pm$

$EI = 533 \pm$

JOB NO. 78.244.1
DATE 6-27-79
BY MA
CH'D BY FDA 7/12/79

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

SHEET NO D 15
JOB Dams
SUBJECT Lowell - Dike
CLIENT Corps

Dike Area Significant to High Hazard

Dike is 1600' long, earth embankment, with concrete core wall (unreinforced). Highest section, 18ft±, occurs near main dam's left abutment and extend u.s. for 300'±. Then decrease to 10' to 15'± at various locations. Assume 0.4 of 300' length fails, with average depth of 18'. Core wall is 4'± ft. below top of dike, this assumes soil cover washes out then a section of core wall fails, allowing the release of water.

Failure Outflow

$$Q_B = 8/27\ (0.4 \times 300.)\sqrt{32.2}\ (18.)^{1.5} = 15{,}400.^{\pm}\ cfs$$

Station	Flow	Flood Stage	Flood Elev	Damage
0+00	15400.	18'.	770.'	Dike Failure.
3+50	15000	6'	711	1 House, Rd (1).
5+00	14880.	12.	702'	
10+00	14470.	9.	674.	1 House, Rd.
15+00	14000.	9.'	659±	
20+00	13516.	9.	639.	
25+00	13100.	8.	608.	
30+00	12635.	5.	583.	{ 1 House (1'±).
35+00	12145.	4.	566.	{ 1 House (4'±).
40+00	take Flooding from Lowell Spillway outflow 4000±cfs also occuring at Fisher-Pindge Road Area.			{ 2 Houses (4'±). { 1 House (1'±).

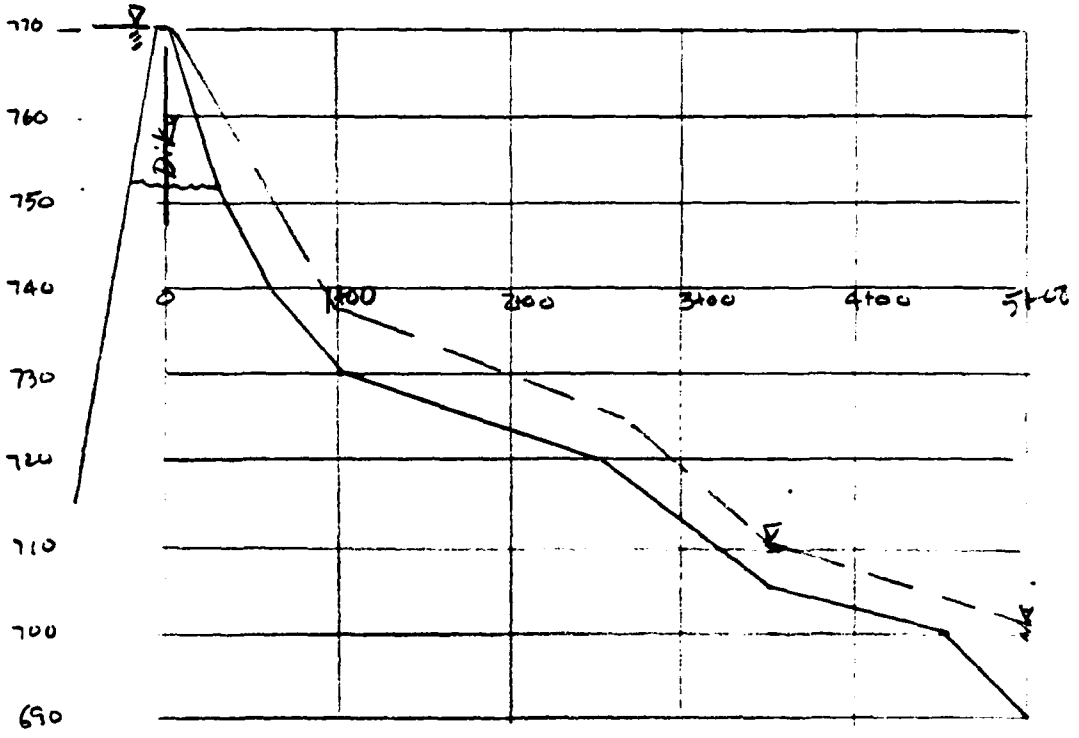
JOB NO. 78244
DATE 5-27-79
BY MA
CH'D BY TDD 7/12/79

HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

SHEET NO. B.16
JOB Dams
SUBJECT Lowell
CLIENT COE

Sta 1400 Sheetflow

QP_1 = 15,400. cfs



JOB NO. 79244
DATE 6-27-79
BY MA
CH'D BY FDD 7/12/79

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON, MASSACHUSETTS

SHEET NO D-
JOB Dams
SUBJECT Lowell
CLIENT CCE

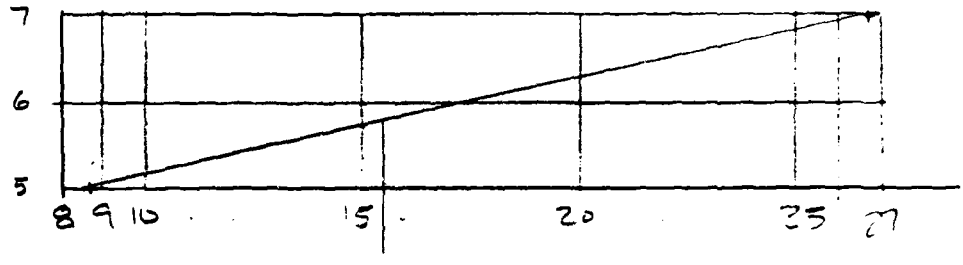
Sta 3+50

$n = 0.10$

$S^{1/2} = (30/250)^{1/2} = 0.346$

$V = \frac{1.486}{0.1} R^{2/3} S^{1/2} = R^{2/3}\ 5.15$

D	W	A	$R^{2/3}$ 5.15	V	Q
3	180	270	1.31	"	6.76	1824
5	550	1070	1.56	"	8.04	8607
7	720	2350	2.2	"	11.4	26734



$Q_{P_1} = 15{,}400$ cfs $El_1 = 5.75$'

$V_1 = \frac{1550 + 2160}{2}\left(\frac{350}{43560}\right) = 14.9$ a-f < S/2 oc

$S = 583$ a-f $\frac{S}{2} = 292$ a-f

$Q_{P_2} = 15400\left(1 - \frac{14.9}{583}\right) = 15000\pm$

$El_2 = 5.6$' $V_2 = \frac{1454 + 2160}{2}(\quad) = 14.5$

$Q_{P_3} = 15400\left(1 - \frac{14.7}{583}\right) = 15{,}012$ cfs

$El_{(1)} = 711\pm$

(allowing for base flow at each section)

JOB NO. 78244
DATE 6-27-79
BY MA
CH'D BY FDD 7/12/79

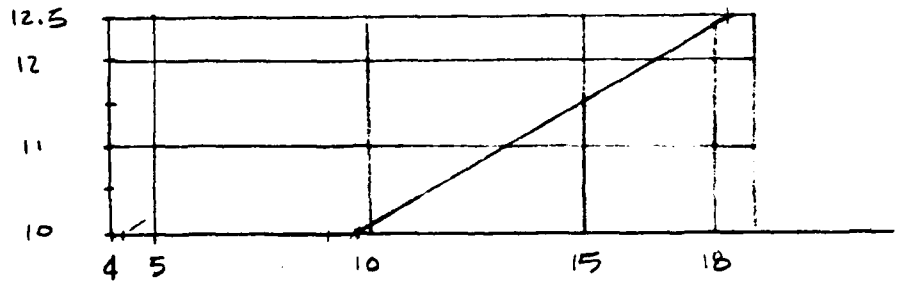
HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON, MASSACHUSETTS

SHEET NO D-9
JOB Dams
SUBJECT Loveal
CLIENT COE

Std 5+00 first section w/ flow inside brook channel

$S^{1/2} = (25/500)^{1/2} = 0.224$.
n = shrubs, trees = 0.10.
$V = \frac{1.486}{0.1} R^{2/3} S^{1/2} = R^{2/3}\, 3.32$.

D	W°	A	$R^{2/3}$	F'	V	Q
5.	105	250	1.79.	3.32	5.95.	1491.
7.5	155	600	2.48.	"	8.26.	4953.
10.	205	1000	2.89.	"	9.62.	9620
12.5	260	1625	3.4.	"	11.3.	18390.



$Q_{P_1} = 15012$ $El_1 = 11.5$ $V_1 = \frac{1400 + 1500}{2}\left(\frac{15}{43560}\right) = 5.$

$Q_{P_2} = 15012\left(1 - \frac{5}{583}\right) = 14883.$ $El_2 = 11.5\pm$

$V_2 = \frac{1315 + 1500}{2}(\ ) = 5.$ $V_a = 5.\pm$.

$Q_{P_3} = 15012\left(1 - \frac{5}{583}\right) = 14380\pm$

$Elev = 690 + 11.5 = 701.5\pm$.

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CONSULTING ENGINEERS
BOSTON, MASSACHUSETTS

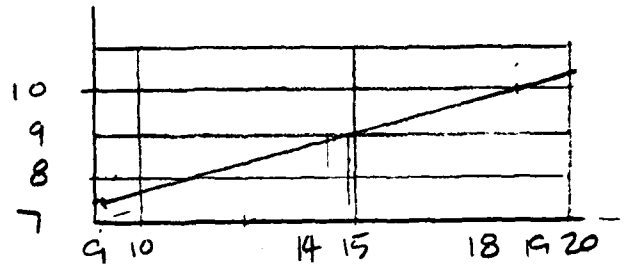
Std 10+00

$n = 0.10$

$S^{1/2} = (25/500)^{1/2} = 0.224$

$V = \frac{1.486}{0.1} R^{2/3} (.224) = 3.32$

D	WP	A	$R^{2/3}$	F'	V	Q
5	190	490	1.89	3.32	6.29	3083
10	280	1690	3.33	"	11.08	18732
7.5	240	1030	2.65	"	8.83	9098



$Q_{Y_1} = 14{,}880$ $El_1 = 9$

$V_1 = \frac{1426 + 1385}{2} (.0115) = 16.16$

$Q_{Y_2} = 14880 \left(1 - \frac{16.16}{583}\right) = 14{,}467$

$El_2 = 8.8$ $V_2 = \frac{1373 + 1385}{2} (.0115) = 15.80$

$Q_{Y_3} = 14880 \left(1 - \frac{16.01}{583}\right) = 14{,}471$

$El_{av} = 8.8 + 665 = 673.8 \pm$

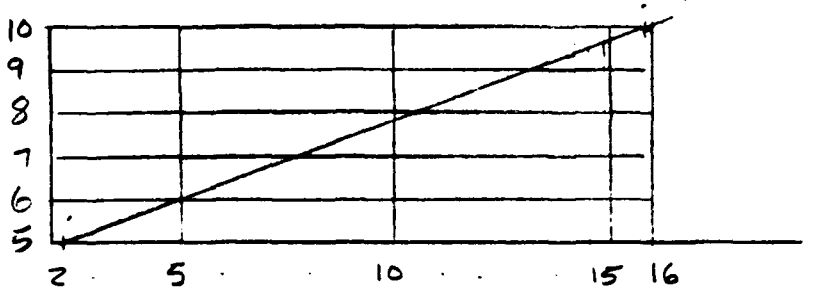
Std 15+00

$n = 0.10$

$S^{1/2} = (15/500)^{1/2} = 0.1732$

$V = \frac{1.486}{0.1} R^{2/3} S^{1/2} = R^{2/3}(2.574)$.

D	WP	A	$R^{2/3}$	F'	V	Q
5	230	500	1.68	2.574	4.3	2165;
10	460	2175	2.83	"	7.3	15853;



$Q_{P_1} = 14470$. $El_1 = 9.5$.

$V_1 = \frac{2008 + 1400}{2}(0.0115) = 19.6$.

$Q_{P_2} = 14470.\left(1 - \frac{19.6}{583}\right) = 14000\pm$

$El_2 = 9.3$.

$V_2 = \frac{1941 + 1400}{2}(.0115) = 19.2$. cwp = 19.4.

$Q_{P_3} = 14470.\left(1 - \frac{19.40}{583}\right) = 14000.\pm$

$EQ_{ew} = 659.3\pm$

JOB NO. 78244
DATE 6-27-79
BY MA
CH'D BY FDD 7/12/79

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON, MASSACHUSETTS

SHEET NO. B-21
JOB Tasks
SUBJECT Lowell
CLIENT COE

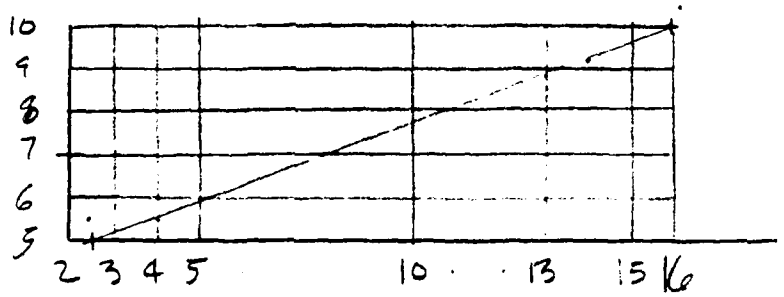
Sta 20+00

$n = 0.10$

$S^{1/2} = (22/500)^{1/2} = 0.21$

$V = R^{2/3}\ 3.12$

D	WP	A	$R^{2/3}$	3.12	V	Q
5	175	438	1.85	"	5.76	2527
10	360	1763	2.89	"	9.04	15,947
12	385	2503	3.51	"	11	27313
11	370	2143	3.24	"	10.1	21,690



$Q_{P_1} = 14000 \quad E_1 = 9.2$

$V_1 = \frac{1551 + 1970}{2}(0.0115) = 20.25$

$Q_{P_2} = 14000\left(1 - \frac{20.25}{583}\right) = 13,514$

$E_2 = 9.1 \quad V_2 = \frac{1525 + 1970}{2}(.0115) = 20.1$ ave 20.18

$Q_{P_3} = 14000\left(1 - \frac{20.18}{583}\right) = 13516$ cfs

Elev = 639.1 ±

JOB NO. 78244
DATE 6-27-79
BY MA
CH'D BY FDD 7/12/79

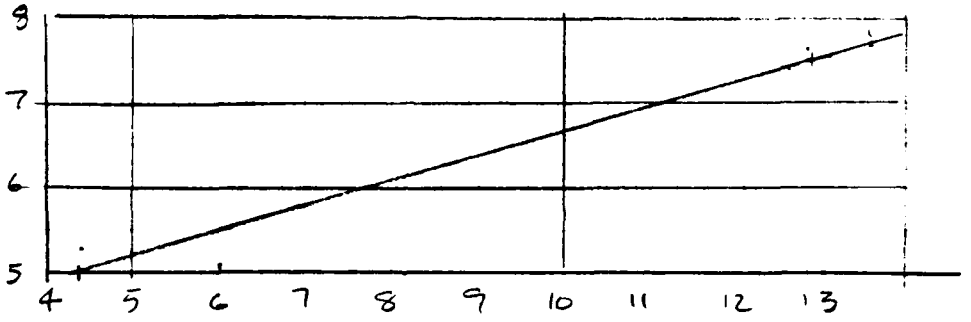
HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON, MASSACHUSETTS

SHEET NO D-2
JOB Davis
SUBJECT Lowell
CLIENT COE

Sta 25+00

$n = 0.10$.
$S^{1/2} = (25/500)^{1/2} = 0.224$.
$V = R^{2/3}(3.32)$

D	WP	A	$R^{2/3}$	3.32 · V	Q
5	270	700	1.89 ·	" ·	6.29 · 4400 ·
7.5	380	1525	2.54 ·	" ·	8.42. 12845 ·



$Q_{P_1} = 13516 \cdot \quad El_1 = 7.7$

$V_1 = \frac{1591 + 1542 \cdot}{2}(0.0115) = 18.00 \cdot$

$Q_{P_2} = 13516 \cdot \left(1 - \frac{18 \cdot}{583}\right) = 13098 \cdot$

$El_2 = 7.55 \cdot$

$V_2 = \frac{1558 + 1540 \cdot}{2}(.0115) = 17.81 \cdot$ ave 17.91 ·

$Q_{P_3} = 13516\left(1 - \frac{17.91}{583}\right) = 13100 \cdot$

Elev = 607.5 ±

JOB NO. 78244
DATE 6-27-79
BY MA
CH'D BY F.DA. 7/12/79

HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

SHEET NO. 22
JOB Dam
SUBJECT Lowell
CLIENT CoE

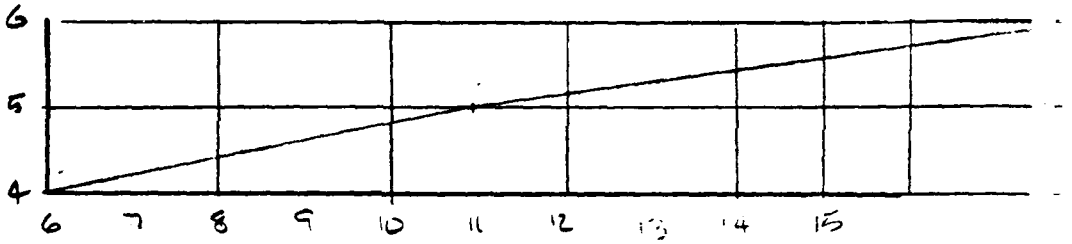
Sta 30+00

$n = 0.10$

$S^{1/2} = (18/500)^{1/2} = 0.19$

$V = R^{2/3}\ 2.82$

D	WP	A	$R^{2/3}$	2.82 · V	Q
5	610	1850	2.10	"	5.93	10,971.
4	590	1275	1.67	"	4.72	6,025.
6	655	2560	2.49	"	7.02	18,000.



$Q_{P_1} = 13100 \cdot \quad El_1 = 5.3$

$V_1 = \frac{2063 + 1575}{2}(0.0115) = 20.92$

$Q_{P_2} = 13100 \cdot \left(1 - \frac{20.92}{583}\right) = 12630$

$El_2 = 5.2 \quad V_2 = \frac{1992 + 1575}{2}(.0115) = 20.51$

$Q_{P_3} = 13100 \cdot \left(1 - \frac{20.72}{583}\right) = 12635$ ~~cfs~~

Elev = 583.2 ±

JOB NO. 70244
DATE 6-27-79
BY mt
CH'D BY FDD 7/12/79

HH&B HAYDEN, HARDING & BUCHANAN, INC
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

SHEET NO 24
JOB Davis
SUBJECT Level II
CLIENT COE

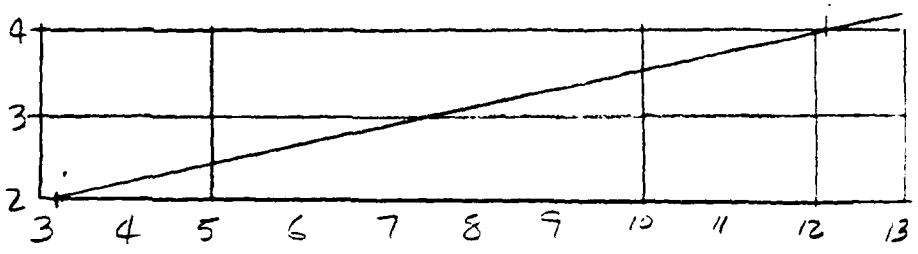
5+00 to 35+00

$n = 0.10$

$S^{1/2} = (19/500)^{1/2} = 0.195$

$V = \frac{1.486}{n}(R^{2/3})(0.195) \cong 2.9 \cdot R^{2/3}$

D	WP	A	$R^{2/3}$	$2.9 \cdot R^{2/3}$	V	Q
2	500	800	1.37	"	4	3200
4	570	1880	2.22	"	6.45	12,128



$Q_{P_1} = 12635 \cdot E_1 = 4.1$

$V_1 = \frac{1934 + 2025}{2}(0.0115) = 22.76$

$Q_{P_2} = 12635\left(1 - \frac{22.76}{583}\right) = 12142$

$E_2 = 4 \quad V_2 = \frac{1880 + 2025}{2}(\ ) = 22.45$

$Q_{P_3} = 12635\left(1 - \frac{22.61}{583}\right) = 12,145$

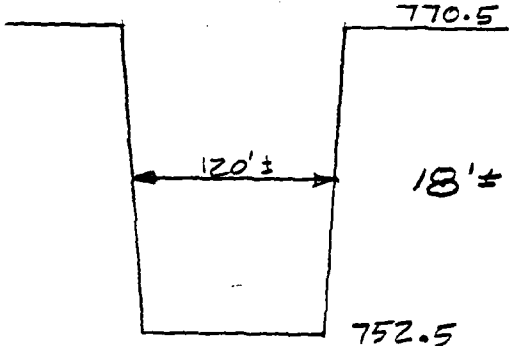
Elev = 566.

JOB NO. 78244
DATE 6-27-79
BY MA
CH'D BY FDD

HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON MASSACHUSETTS

JOB Dams SHEET NO. 2
SUBJECT Lowell
CLIENT COE

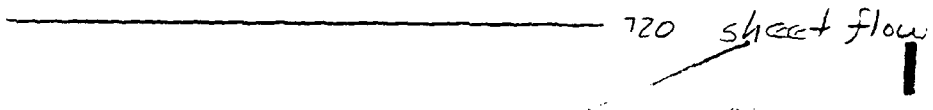
0+00



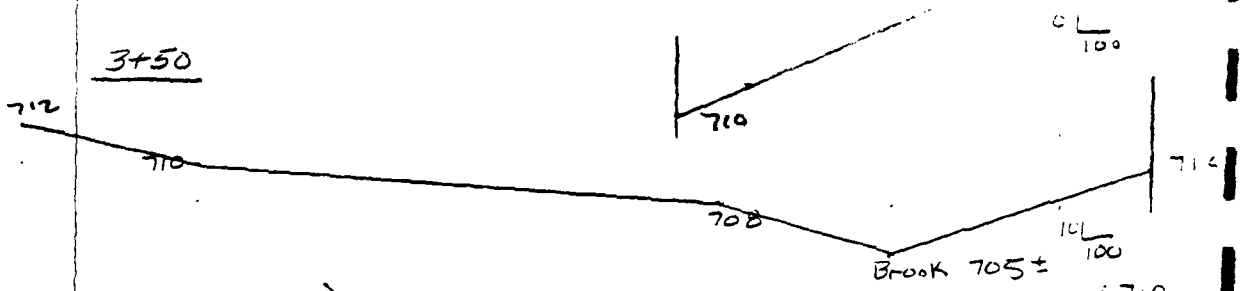
Scale ↑10 →100 unless noted otherwise

1+00

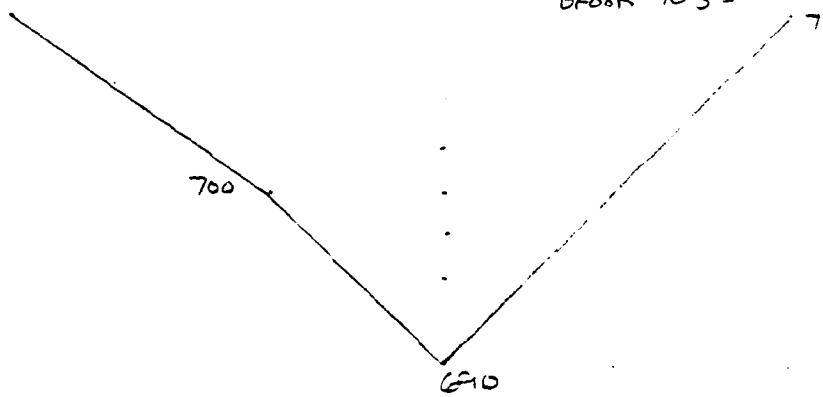
2+50



3+50



5+00

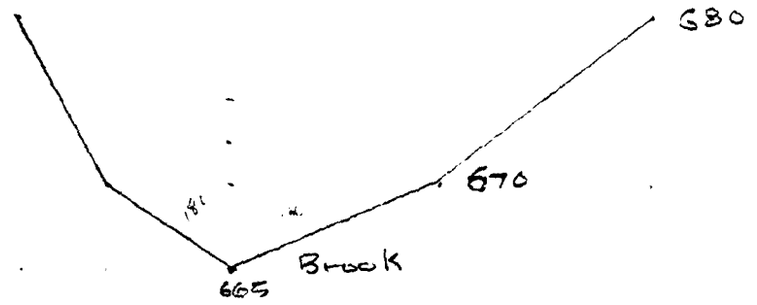


JOB NO. 78244
DATE 3-27-79
BY MA
CH'D BY FDD

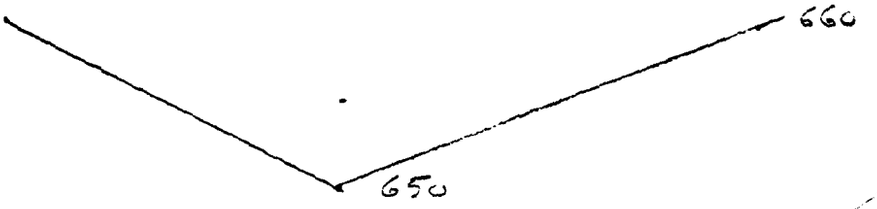
HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON, MASSACHUSETTS

SHEET NO D-2
JOB Dams
SUBJECT Cowell
CLIENT CCE

10+00



15+00



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25+00

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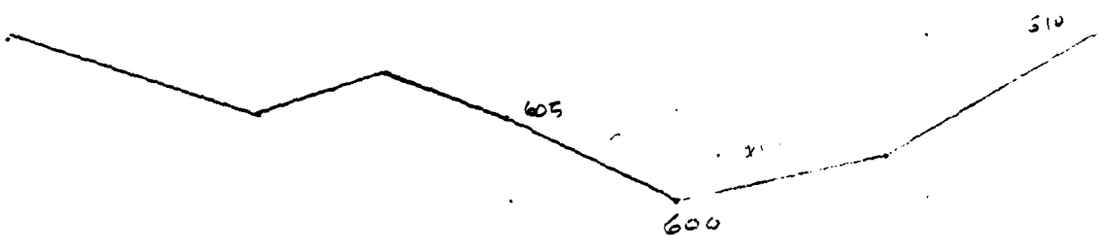
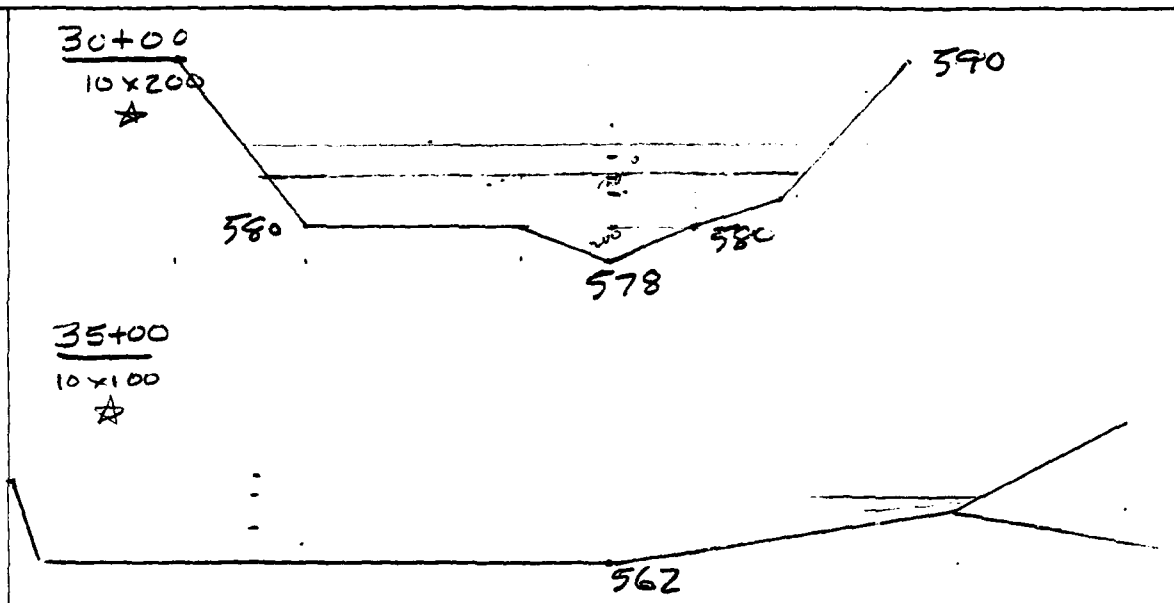
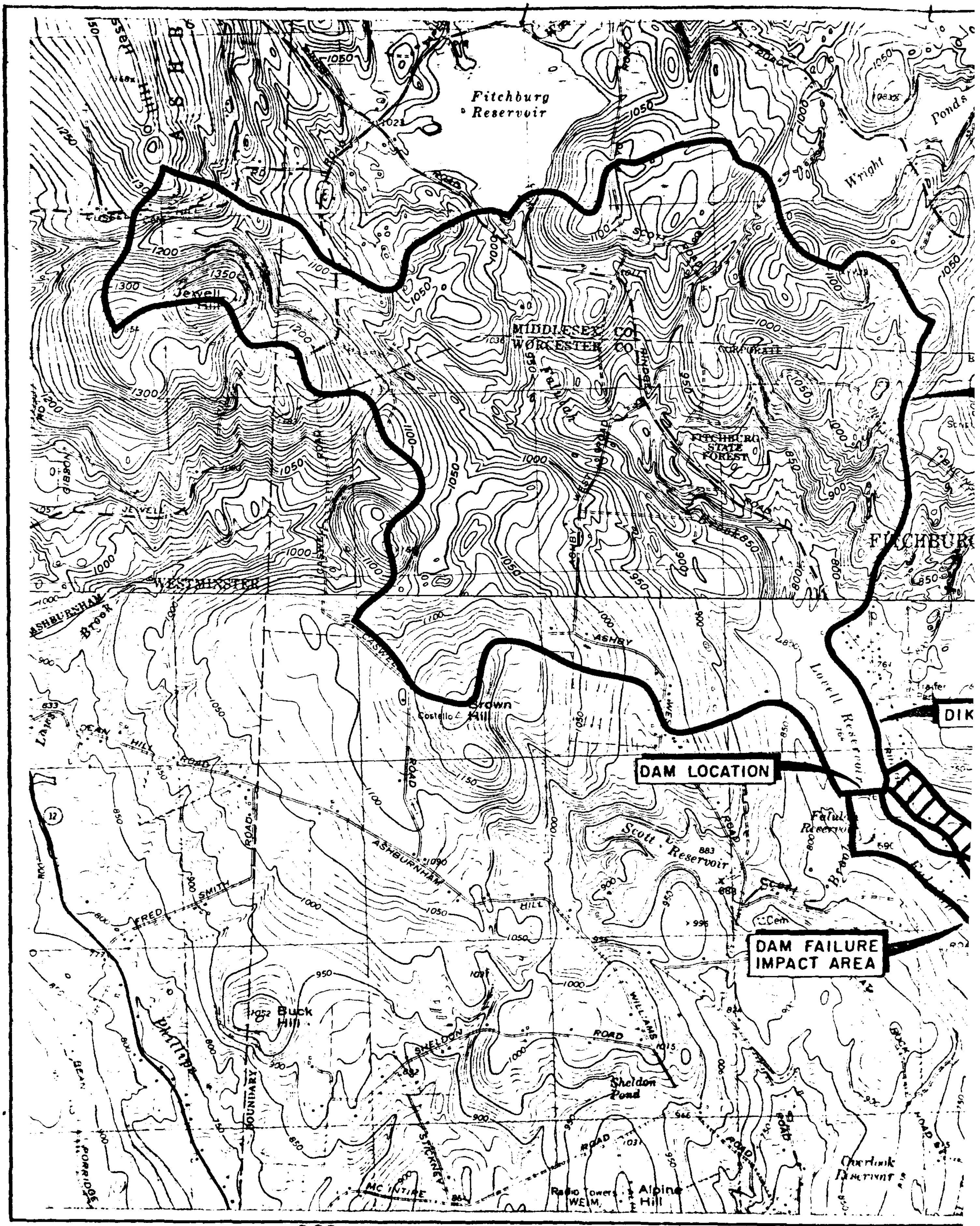


JOB NO. 78244
DATE 6-27-79
BY MA
CH'D BY FDD

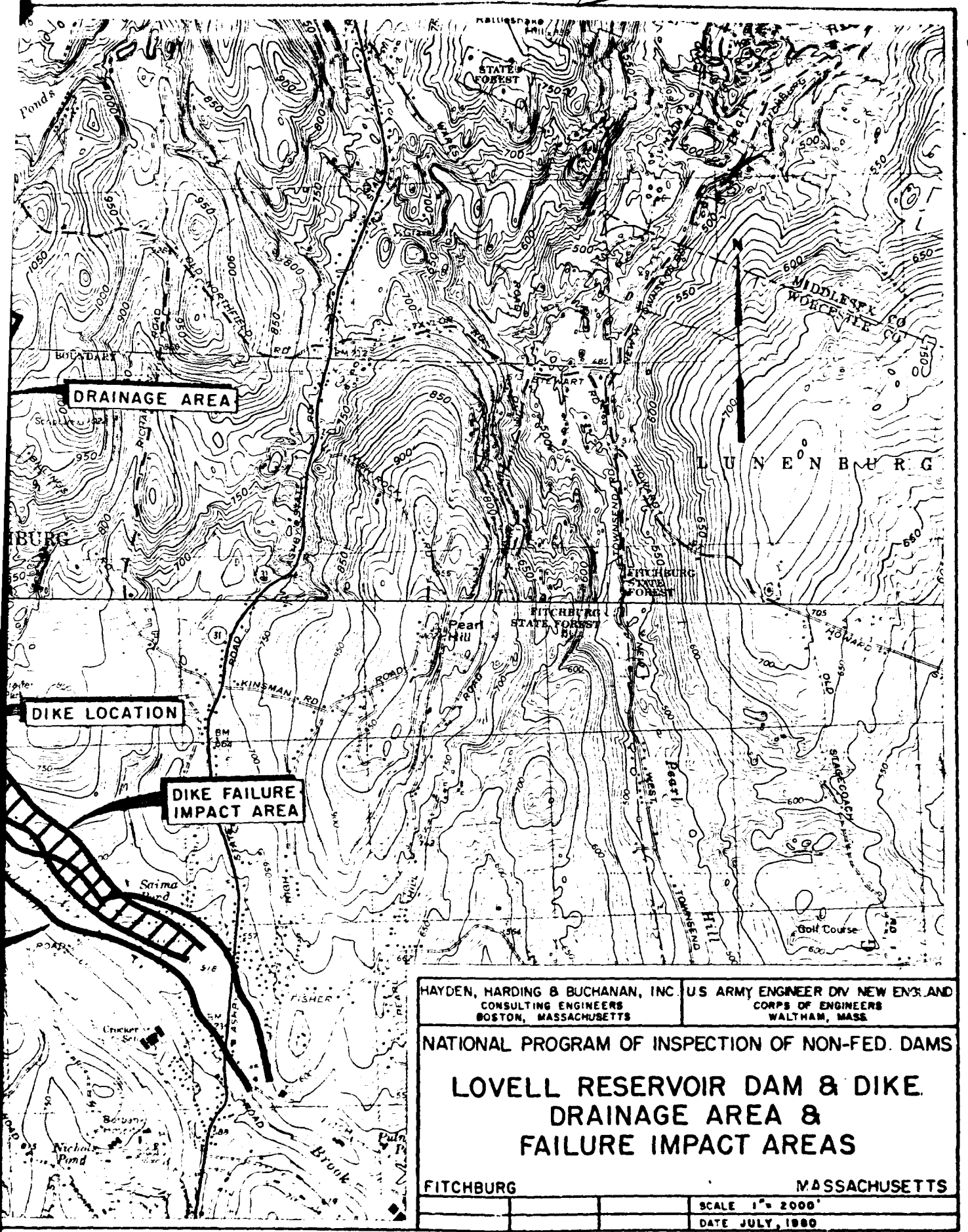
HH&B HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON, MASSACHUSETTS

SHEET NO D-7
JOB Davis
SUBJECT Lowell
CLIENT COE





Fitchburg Reservoir
Jewell Hill
MIDDLESEX CO
WORCESTER CO
FITCHBURG STATE FOREST
WESTMINSTER
Ashburnham Brook
Brown Hill
Costello
DAM LOCATION
Scott Reservoir
DAM FAILURE IMPACT AREA
Buck Hill
Sheldon Pond
Radio Towers WEIM
Alpine Hill
Lovell Reservoir
Wright
Ponds



HAYDEN, HARDING & BUCHANAN, INC. CONSULTING ENGINEERS BOSTON, MASSACHUSETTS	U.S. ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOVELL RESERVOIR DAM & DIKE
DRAINAGE AREA & FAILURE IMPACT AREAS

FITCHBURG MASSACHUSETTS

SCALE 1" = 2000'

DATE JULY, 1980

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

(1) STATE	(2) IDENTITY NUMBER	(3) DIVISION	(4) STATE	(5) COUNTY	(6) CONGR DIST.	(7) STATE	(8) COUNTY	(9) CONGR DIST.	(10) NAME	(11) LATITUDE (NORTH)	(12) LONGITUDE (WEST)	(13) REPORT DATE DAY | MO | YR
MA	1334	NED	MA	027	04				LOVELL RESERVOIR DIKE	4237.1	7149.3	31JUL80

(14) POPULAR NAME	(15) NAME OF IMPOUNDMENT
	LOVELL RESERVOIR

(16) REGION	(17) BASIN	(18) RIVER OR STREAM	(19) NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	(20) DIST FROM DAM (MI.)	(21) POPULATION
01	09	FALULAH BROOK	FITCHBURG	0	38976

(22) TYPE OF DAM	(23) YEAR COMPLETED	(24) PURPOSES	(25) STRUCTURAL HEIGHT (FT.)	(26) HYDRAULIC HEIGHT (FT.)	(27) IMPOUNDING CAPACITIES MAXIMUM (ACRE–FT.)	(27) IMPOUNDING CAPACITIES NORMAL (ACRE–FT.)	DIST	OWN	FED R	PHV/FED	SCS A	VER/DATE
REPGUT	1929	S	27	18	1173	914	NED	N	N	N	N	31JUL80

(28) REMARKS
21 CONCRETE COVERALL

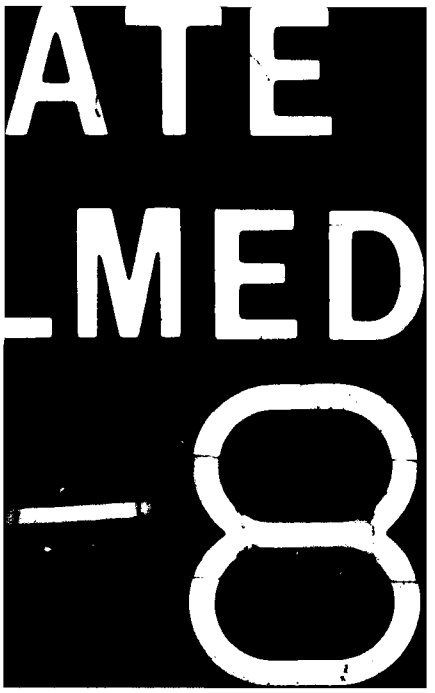
(29) D/S HAS	(30) SPILLWAY CREST LENGTH	(30) SPILLWAY TYPE	(30) SPILLWAY WIDTH (FT.)	(31) MAXIMUM DISCHARGE (FT.)	(32) VOLUME OF DAM (CY)	(33) POWER CAPACITY INSTALLED (MW)	(33) POWER CAPACITY PROPOSED (MW)	(34) NAVIGATION LOCKS NO.	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
1	1600	U	78	4328												

(35) OWNER	(36) ENGINEERING BY	(37) CONSTRUCTION BY
CITY OF FITCHBURG	UNKNOWN	KEATING OF FITCHBURG

(38) REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	NONE

(39) INSPECTION BY	(40) INSPECTION DATE DAY | MO | YR	(41) AUTHORITY FOR INSPECTION
HAYDEN HARDING & BUCHANAN INC	17JUN80	PL 92-367

(42) REMARKS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